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CONTENTS

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THE CHEMICAL AND MECHANICAL UTILIZATION OF ACTIVATED CARBON IN WATER PURIFICATION[1]

BY A. S. BEHRMAN[2] AND H. B. CRANE[3]

A year ago, at the Toronto meeting of this Association, John R. Baylis presented a strikingly comprehensive survey[4] of the characteristics of a number of commercial activated carbons and of their possible application to water purification. As a result of his experimental work carried on in connection with this survey, Mr. Baylis concluded that very definite and promising possibilities existed for activated carbon in water purification practice, particularly in the removal of tastes and odors occasioned by chlorine, phenols, chlorphenols, and related compounds.

In the year that has elapsed, it has been the pleasure of the writers of this paper, and of the organization with which they are associated, to cooperate in an honest effort to determine the legitimate place of activated carbon in water purification practice, and to devise practical methods and equipment for employing the carbon in its proper fields of use.

The function of the present paper is to give a threefold progress

[1] Presented before the Water Purification Division, the St. Louis Convention, June 4, 1930.

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[4] Journal, June, 1929, page 787.

report on what has been accomplished in the development of principles for the proper design and operation of equipment for using the carbon; on the results from actual installations made within the past year; and on suggestions for new applications of the carbon to water purification processes.

UTILITY HAS BEEN DEMONSTRATED

Although a year is a very short time in which to accumulate much full scale field experience with a new development of this sort, we have been unusually fortunate in having been able to install a number of fairly large industrial plants and several small experimental units in municipal plants from which a good deal of significant information has been obtained.

The uniform and complete success of all these installations afford convincing proof of the utility and commercial practicability of the proper sort of carbon in a wide variety of water purification problems.

Included in the industrial installations may be listed several in packing and other food product plants with daily capacities of a quarter million gallons or over; and a considerable number of smaller installations, ranging from fifty thousand gallons downward, in a wide variety of locations, such as bottling plants, hotels, ice plants, department stores and private estates.

The use in bottling plants is particularly interesting in that carbon bids fair to displace the ozone treatment that has been used quite extensively—and expensively—in this field for the removal of tastes and odors from water to be used in bottled beverages.

In the municipal field, two experimental units have been installed within the last year, and a third is just going in now. In addition, small scale laboratory tests are being conducted in a number of municipal plant laboratories.

It will be noted that, in the municipal water purification field, carbon installations have so far been confined to experimental units. Municipalities are necessarily slower to act than industry in accepting innovations of any kind. This is true not only because of the nature and the organization of the municipal machinery provided for the purpose, but also because of the fact that the considerations involved in the treatment of a municipal water supply are frequently quite different in some respects than those encountered in the handling of an industrial supply. These diverse considerations will be referred to again.

THE FIELD FOR ACTIVATED CARBON

In attempting to evaluate accurately the utility of activated carbon for water purification, both economic and esthetic considerations must be given proper attention. In so doing, at least three questions will naturally be formulated by the engineer and chemist:

(1) What will the carbon treatment accomplish?

(2) What will the carbon treatment accomplish that cannot be secured by other available methods?

(3) How does the cost of the carbon treatment compare with that of other remedies?

A brief answer to each of these questions will be in order.

TYPES OF PURIFICATION POSSIBLE WITH ACTIVATED CARBON

Experiment and full scale experience have demonstrated that the proper sort of carbon may be used successfully in water purification for the removal of practically every kind of organic taste and odor, for the elimination of free chlorine, for the removal of organic coloring matter, and for the separation and removal of iron.

The removal of the organic matter is effected either by direct adsorption by the carbon, or by using an excess of chlorine to destroy the organic matter as completely as possible, following this superchlorination by treatment with carbon to remove the excess chlorine. As Mr. Baylis has pointed out, it is generally much more preferable to employ the latter method. If the carbon is used simply as an adsorbing agent for the impurities, its active life will obviously be limited to its adsorptive capacity; and when this capacity is exhausted, the carbon must either be revivified or thrown away. If, on the other hand, the carbon is used primarily as a dechlorinating agent, following the destruction of the organic matter by superchlorination, there is obviously much less likelihood of the pores of the carbon being choked with organic matter; and the residual free chlorine applied to the carbon is in itself a revivifying agent.

The removal of color by means of superchlorination and dechlorination with carbon is a very promising field and one that deserves more attention. Our laboratory studies have indicated that, in the case of turbid colored waters, the method will frequently be found a valuable and economical adjunct to the usual coagulation and filtration processes; while in the case of clear colored waters, coagulation and sand filtration may sometimes be dispensed with entirely.

In iron removal with carbon, the ferrous iron in the raw water is

oxidized practically instantaneously to ferric iron by means of an excess of chlorine. The ferric iron thus formed hydrolyzes almost immediately—in any normally alkaline water—to yield insoluble ferric hydroxide. This ferric hydroxide is removed from the water by appropriate means, and the residual free chlorine then removed by carbon. The principal advantage of this iron removal process will be in closed systems, where it will eliminate both the necessity for the double pumping usually involved in aeration and the absorption of oxygen which sometimes results in a corrosion more objectionable than the original iron content.

SPECIFIC ADVANTAGES OF THE CARBON TREATMENT

The advantages of the carbon treatment, within its proper field of application, reside both in the purification accomplished and in the striking simplicity and ease of operation.

It is not the intention of this paper to suggest that carbon is a panacea for all the ills with which a water supply may be afflicted. Neither is its purpose to discuss at length the relative merits of carbon treatment and those of sulfur dioxide, ammonia, permanganate and any other methods of taste and odor removal which have been suggested. When more complete and definite information has been accumulated, all of these methods will probably be shown to have their proper place under the special set of conditions in which the use of one or the other is indicated.

It will be sufficient here merely to point out that in the two experimental units in municipal plants referred to previously, it has been found that the carbon treatment effects a removal of taste and odor which had been found impossible with any of the other three methods just named. An analysis of the mechanism of the various methods of taste and odor removal will suggest perfectly logical reasons for their limitations; but such an analysis is outside the province of this paper.

There are a number of distinctive operating advantages in typical carbon treatment. By "typical treatment" we mean here the regular passage of superchlorinated water through a bed of the carbon. It might well be said that the principal operating advantage is that practically no operation is required. The carbon functions automatically, accurately, constantly. No lookout is necessary to detect the occurrence of taste in the raw water. No feeding device is necessary to proportion a reagent with the exactness which is required to counter-

act the taste and yet not impart a taste-producing or wasteful excess of the reagent. The carbon may be said to combine the functions of a watch dog and the police department, meeting the emergency automatically and fully whenever it arises.

An incidental but important application of the automatic corrective characteristics of carbon is in the sterilization of relatively small community water supplies. In a great many cases of this sort, where only occasional supervision is possible, the dosage of chlorine is based on the normal demand for water. During the night, or at other times when the load drops below this normal demand, the dosage of chlorine frequently increases to a point where objectionable tastes and odors are produced. A carbon treatment unit placed in the line before the water enters the distribution system will automatically prevent the occurrence of chlorine tastes and odors.

THE COST OF CARBON TREATMENT

What is the cost of carbon treatment? No one answer to this question can be given that will fit all cases, partly because the considerations influencing the cost may vary widely in different instances, and partly because our knowledge of the life of the carbon under different conditions is still incomplete.

The principal factors involved in the cost of the carbon treatment are the usual ones: Installation, operation and maintenance, overhead and depreciation. The cost of installation will depend largely on whether or not a new plant is to be built, or whether an existing plant must be utilized as far as possible. Examples of both types of installations will be described later.

The cost of operation is practically negligible. Only a nominal amount of attention is required, consisting for the most part in washing the carbon units at intervals of one to six months. This factor is obviously of great importance to industrial and small municipal plants, but has less significance in large municipal or industrial plants already provided with a well trained technical staff.

Depreciation is largely a question of the life of the carbon. On this point our information is admittedly incomplete, due principally to the fact that in none of the plants that we have installed has revivification or replacement of the carbon yet been necessary. It will be of interest, however, to mention here that, operating on the Chicago water supply, the activated carbon equipment of the writers' organization is guaranteed to remove all tastes due to chlorine,

chlorphenols, and related substances for a period of two years; and we have good reason to believe that the active life of the carbon under these conditions will be at least twice the guaranteed period before revivification is required.

Such long periods of uninterrupted service naturally suggest that replacement may be more economical in some cases than revivification. They would also seem to indicate quite definitely that, when revivification is employed and the maximum life of the carbon is thus utilized, the cost of carbon for taste and odor removal will compare very favorably with that of even the cheapest of other methods.

In the paper that follows on this program,[5] we understand that Mr. Baylis will give considerable data on the life and revivification of carbon. We shall therefore pass over these two phases of the subject without detailed discussion. We may point out, however, that carbon used in water purification requires a method of revivification which applies specifically to that use; and that methods of reactivation of the carbon used in other arts may not function at all satisfactorily in water purification. In solvent recovery, for example, activated carbon used for adsorption of solvent vapors may be revivified very successfully with live steam; but freeing the carbon from adsorbed vapors is quite a different problem than freeing it from the gelatinous organic and inorganic substances which have choked the pores; and revivification with steam cannot logically be expected to give eminently satisfactory results in the latter case.

Of the several methods proposed for revivifying carbon used in water purification, treatment with an alkaline solution appears to us at this time to be the most generally desirable and practical for the removal of adsorbed gelatinous organic and inorganic impurities, while revivification with steam appears perferable for the removal of adsorbed volatile taste and odor producing compounds.

CHOICE OF THE PROPER CARBON

The great progress in the carbon treatment of water in the last year has been made possible largely by the development of a relatively low-priced granular carbon. It is evident that such a carbon must possess the proper physical as well as chemical characteristics. It must have sufficient mechanical strength to resist crushing and attrition; it should be heavy enough to permit an upward flow of water

[5] Journal, page 1414.

through it at reasonable rates of flow without tending to float out of the container; and added to these physical characteristics it should have sufficient activity per unit volume such as not to require a container of excessive size.

The activity should be specific towards the water purification desired. Not all types of activated carbon possess the proper kind of activity. For example, an excellent gas carbon—that is a carbon used for the adsorption of gases and vapors—is quite frequently a poor decolorizing carbon, which appears to be the type best suited to the general requirements of water purification.

The carbon employed by the writers' organization is known as "Hydrodarco" and is the particular grade of Darco used so successfully by Mr. Baylis in the paper[4] presented before this Association last year. This carbon was selected by us after a thorough study and comparison of it with other materials available; and the results we have obtained from it in the past year have, we believe, fully justified our selection.

"Hydrodarco" is made by special processing of certain Texas lignites. It is regularly supplied in granular form screened 4 to 12 mesh. Although its air dry weight is only 18 pounds per cubic foot, its effective weight in water is so great than an upward flow of 12 to 15 gallons per square foot per minute requires no more free board for expansion than the ordinary sand filter. "Hydrodarco" contains about 70 percent of pure carbon, with a siliceous skeleton giving it ample mechanical strength.

A powdered form of "Hydrodarco" has recently become available; and we look forward to interesting developments in the employment of this material, especially in municipal water purification for emergency use.

DESIGN AND OPERATION OF CARBON TREATING EQUIPMENT

We pass now to a consideration of the design and operation of several types of carbon treatment equipment which have been developed for the specific purposes indicated.

In each of the following illustrations, the scheme of operation shows that (1) "Hydrodarco" treatment follows sand filtration; (2) separate containers or basins are provided for the sand and the carbon; and (3) "upflow" operation through the latter is indicated. These three features are interrelated. The necessity for such arrangement in the first two cases, and the advisability in the third, may be explained

broadly by the fact that an activated carbon is not a filtering medium, and any attempt to use it regularly as such gradually lessens its effectiveness as a purifying agent.

"Hydrodarco" is essentially a contact material, and adsorption takes place at the surface and in the pores of the carbon. If the particles become coated with dirt or suspended matter, the area available for adsorption is reduced. It follows that highest efficiency in using the material for the removal of objectionable compounds can be obtained only when a clean water is applied to it.

It is impractical to place filter sand and gravel and activated carbon in one bed and thus combine the advantages of mechanical filtration and the removal of tastes and odors. Differences in specific gravities of the materials preclude this possibility. While "Hydrodarco," as already stated, has a sufficiently high effective weight in water to permit upward flows through it of 12 to 15 gallons per square foot per minute, with relatively low expansion, the effective weight of filter sand is even greater. If then, a bed of sand is placed in the same container above a bed of "Hydrodarco" with the dual pupose in mind of providing a filtration-purification unit, that purpose will be defeated in the first backwashing, during which the sand will work to the bottom and the "Hydrodarco" rise to the top.

It might seem feasible to confine the carbon below the sand by means of a screen; but this is not the case. While the carbon alone may be operated in a fixed position with a fair degree of satisfaction, it is not worth while to jeopardize to any degree the success of the filtration part of the project by placing the carbon bed in that position since when so placed it may become a distinct handicap to filter operation.

"Upflow" operation with "Hydrodarco" is generally preferable to "downflow" merely because the former provides greater simplicity in plant design and operation. As far as effectiveness of purification is concerned, it is entirely immaterial in which direction a clean water passes through the carbon bed. When the flow through a bed of granular material is downward, loss of head gradually increases, due to the packing of the grains; and while the loss through "Hydrodarco" does not increase nearly as rapidly as the loss through filter sand, it is a variable quantity and should be kept at a minimum if the energy that is expended in delivering the water to the plant is to be utilized to the best advantage. With "upflow" operation the pressure lost in operating the carbon remains practically constant for a

given rate of flow, and is occasioned principally in getting proper distribution through the manifold and laterals.

The simplest and most economical form of filtration-activated carbon installation that can be made consists of a pressure coagulant feeder operated by a differential proportioner installed in the raw water supply line serving the coagulating tank, two pressure filters and two "Hydrodarco" units piped to operate in parallel. Such an installation is suitable for use whenever the capacity required is within the range of this type of construction, and the character of the raw water is such that more elaborate coagulation is not required. The principal operating advantage with such apparatus is derived from the fact that head does not have be restored with separate pumps after purification.

Two-story construction has been suggested by Mr. Baylis to conserve space and facilitate the operation of gravity units. The two-story construction is well suited to the needs of industrial establishments and small communities where the water consumption is only moderately large. Such a plant may be built either of wood or steel, and may frequently be housed in an existing building, thus making it more economical for small capacities than other types of construction. Ground space is saved through the use of a rather high coagulating tank; while the sand filter, located directly above the carbon unit, and in the same tank, makes for compactness and for ease of operation. Automatic devices can be supplied to control all operations at a constant rate. The raw water is delivered to the reaction chamber through an automatic controller which stops and starts the flow to the plant at high and low water levels in the coagulating tank. The raw water controller is also supplied with mechanical means for immediately cutting off the flow of coagulants through the orifice boxes when the raw water supply is shut off.

A switch, also operated by the raw water controller, may be wired to the motor of the raw water supply pump, and so make the water treatment system entirely automatic in operation.

If the water consumption is very nearly constant, as it is in many industrial plants, no reservoir or sump for the purified water need be supplied, as the pressure pump may have its suction connected to the space in the lower compartment directly above the activated carbon bed. In cases of widely fluctuating water demand, the effluent line from the lower compartment may be piped to a sump or reservoir and the purified water pumped from it.

The range of capacities of this type of plant is necessarily limited by construction difficulties. Separate pressure tanks must frequently be provided for sand and carbon, and the water passed through them to a clear well under the head available from the coagulating tank.

Experience in filter plant operation has demonstrated that certain basic principles of design must not be violated, if successful results are to follow. The careful designer, therefore, gives considerable thought to the proper use of the energy that is expended in the operation of the plant. He utilizes to the best possible advantage the space that the plant facilities require, avoids unnecessarily complicated and costly construction, and arranges his layout to provide an orderly method for the progress of the water from one stage of treatment to another. Activated carbon treatment, when required, should be included with other methods in such a way that the added operating expense will be as low as possible, while still permitting complete freedom in operating the sand filters upon which the major burden of purification rests.

There are numerous ways in which "Hydrodarco" may be included in the layout for a new plant. Two-story construction is employed for a reinforced concrete gravity plant in which sand filters and "Hydrodarco" units are both operated from the head created in the coagulating basins. For example, the beds might each contain 360 square feet of area and a design could be economically developed under some conditions up to 10 m.g.d. total capacity without requiring any material change in the dimensions of the structures. It will probably be helpful to compare certain space requirements of such a plant with those of a filter plant of the same capacity since we are all more or less familiar with the latter.

Figure 1 is part of the plan view, showing sand filters located above the "Hydrodarco" units. The proportions and arrangement of the beds follow quite conventional design for units of this capacity, and the width of the pipe gallery is only slightly greater than would be required for filters of the same capacity so grouped.

Figure 2 is in elevation through part of the gallery and a transverse section through one bed. It shows all of the immediate operating piping required and indicates how the flow through the sand and "Hydrodarco" is regulated by one rate controller. Incidentally, nine operating valves are required per unit, not including the one on the line by-passing the "Hydrodarco" bed. This by-pass may or may not be provided, as conditions warrant. Hydraulic operation

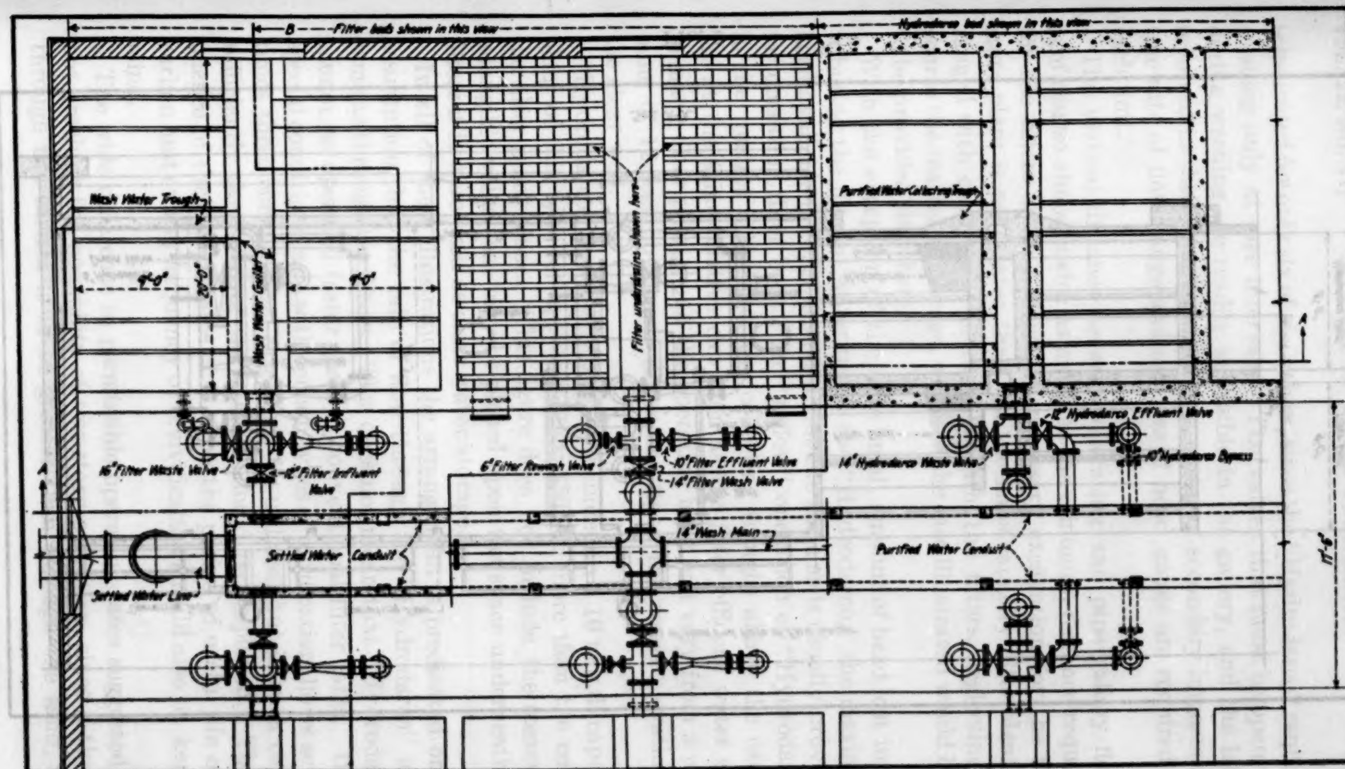
B—Filter beds shown in this view
Hydrodarco bed shown in this view
Wash Water Trough
Wash Water Gutter
20'-0"
9'-0"
9'-0"
Filter underdrains shown here
Purified Water Collecting Trough
12" Hydrodarco Effluent Valve
10" Hydrodarco Bypass
14" Hydrodarco Waste Valve
16" Filter Waste Valve
12" Filter Influent Valve
6" Filter Rewash Valve
10" Filter Effluent Valve
14" Filter Wash Valve
14" Wash Main
Settled Water Conduit
Settled Water Line
Purified Water Conduit
11'-6"

Fig. 1

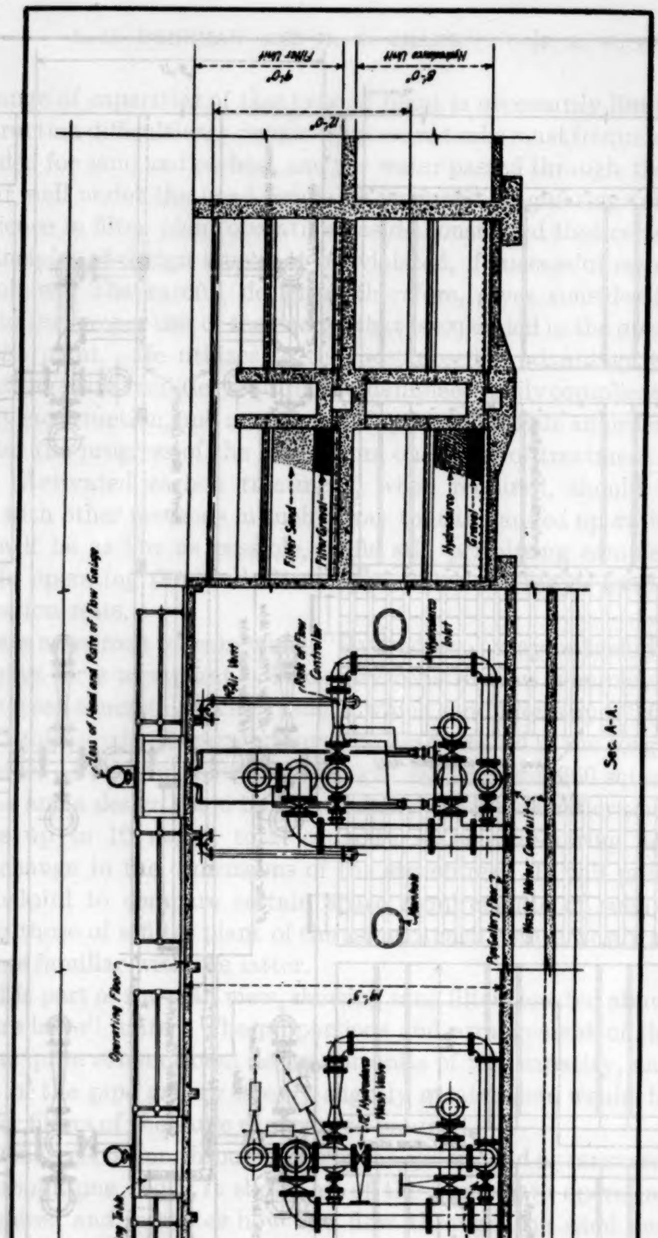
Filter Unit
Hydrodarco Unit
Filter Sand
Filter Gravel
Hydrodarco
Gravel
Loss of Head and Rate of Flow Gauge
Air Vent
Rate of Flow Controller
Hydrodarco Inlet
Operating Floor
Operating Table
Manhole
Pipe Gallery Floor
Waste Water Conduit
Hydrodarco Wash Valve
Hydrodarco Drain Valve
Sec. A-A.

FIG. 2

is indicated for only six of the valves, since the "Hydrodarco" requires washing only at rare intervals. The valves that must be operated during washing are readily accessible in the gallery, and the labor involved in their manipulation is a matter of secondary importance. One rate of flow gauge and one loss of head gauge are required for each unit.

The vertical distance between operating and pipe gallery floors is of course almost twice as much as the minimum distance required for the filters alone. However, necessary excavation for the two-story plant is no greater than for the same capacity filter plant arranged with clear water storage beneath the filters, neglecting, of course the matter of storage, which in the case illustrated would have to be provided elsewhere.

With the exception of the very small amount of head lost in distributing the filtered water under the "Hydrodarco," the maximum head available for operation is about the same as is usually provided for operating filter beds. In "upflow" operation of "Hydrodarco" in the manner suggested, the collecting troughs above the carbon are at the same relative elevation as the filter effluent water seals in many filter plants, and the operating head will vary from a minimum of 12 feet downward depending upon the water elevation in the clear well.

"Hydrodarco" treatment may be included in a 10 m.g.d. capacity plant of this type for approximately $50,000 more than the cost of the filter plant alone. This figure does not include the somewhat intangible value that may be placed upon the space underneath the filters if it were used as clear water storage.

In all of these illustrations the arrangement is predicated on the assumption that the rate of flow through the "Hydrodarco" is the same as through the filters. This does not mean that "Hydrodarco" cannot be operated faster than at conventional filter rates. Under special conditions, and with certain types of purification, flows several times these conventional rates may be utilized; but in such cases a sufficiently deep bed of the carbon should be employed. The influence of these high rates of flow on the period of useful life of the carbon and on the frequency of revivification should also be kept in mind.

The wide difference in permissible operating rates suggested does not preclude the possibility of two-story operation, since if the flow through the carbon is to be greater than through the sand, fewer

"Hydrodarco" beds need be provided, and the filtered water may be collected in headers and redistributed to the carbon beds through seperate rate of flow controllers to make the distribution uniform. In such cases, the space under the filters not occupied by the carbon beds may be utilized to good advantage as clear water storage.

There is an economic limit to the rate at which a carbon bed should be operated, apart from any purification limit. The total capacity for purification per pound of carbon, and the period of operation possible before revivification becomes necessary, bear a definite relationship to the operating rate; and these factors should be well understood before extremely high rates are recommended.

APPLICATION OF CARBON TO EXISTING PLANTS

If 8 to 10 feet of clear well space has been left under the filters, as is so often the case, it can be utilized for two-story operation.

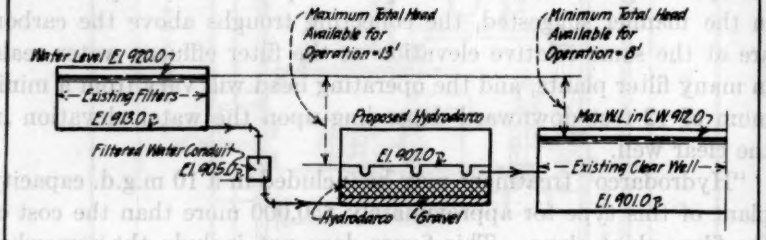

DIAGRAM SHOWING FLOW THROUGH AN EXISTING FILTER PLANT, INDICATING HOW HYDRODARCO TREATMENT MAY BE ADDED.

FIG. 3

Plants originally constructed with clear well located outside of the filter building frequently may have activated carbon treatment added with less disruption to service and operating balance than the case just illustrated. In such plants the carbon beds may be located at any convenient point where space is available between the existing filters and clear well. The flow diagram in figure 3 shows quite clearly the situation at an existing filter plant for which "Hydrodarco" treatment is being investigated, and illustrates how differences in elevations between filters and clear well will very nicely permit the operation of the carbon units. This case is typical of a number of existing filter plants.

CONCLUSION

This paper may well be concluded with the simple summarizing statement that experience in the last year has definitely proven the utility of the proper sort of activated carbon in water purification. A rapidly expanding use of the carbon for this purpose may safely be predicted.

ACTIVATED CARBON FOR THE REMOVAL OF TASTE AND ODOR.[1]

By George D. Norcom,[2] and R. I. Dodd[3]

During the past two years a considerable amount of attention has been directed to the use of activated carbon for the removal of odor and taste from water supplies. The experimental work which has come to our attention has dealt particularly with the removal of residual chlorine, phenols and chlorophenols. The studies described in this paper have been carried out on river water which had been purified by passage through a rapid sand filter plant. The raw water contained objectionable odors and tastes all of the time and the filtered water contained them to a lesser extent the greater part of the time. These odors and tastes are not due to any one substance, but rather to a mixture of substances and at no time could the odor or taste of phenols be specifically detected. The activated carbon has been used in the treatment of this water in such a manner as would be indicated in actual purification practice so that the results should be truly comparable to those which might be secured with a large scale plant.

DESCRIPTION OF RAW WATER

The raw water for the purification plant was secured from the Delaware River at Chester, Pa. The watershed of the Delaware includes a very highly developed industrial territory with manufacturing plants of almost every type. The wastes from most of these plants eventually reach the river and many of them are of such a nature as to cause objectionable taste and odor in water. The odors most frequently encountered are those caused by the wastes from oil refineries, paper mills, chemical plants and organic matter of domestic origin. With the large dilution afforded by the river and the slow progress of the pollution downstream due to ebb and flow of the tides, the agencies

[1] Presented before the Water Purification Division, the St. Louis Convention, June 4, 1930.

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TABLE 1

Intensity of Odors (1929)

(Monthly averages)

MONTH	RAW WATER Hot	RAW WATER Cold	PLANT TREATED WATER Hot	PLANT TREATED WATER Cold
January	3.5	4.7	1.15	0.73
February	5.0	5.0	1.26	0.96
March	4.3	4.6	1.44	0.90
April	3.7	3.9	0.92	0.63
May	2.9	3.4	1.00	0.54
June	3.0	2.8	1.19	0.65
July	2.8	2.7	0.96	0.39
August	3.8	3.7	1.16	0.26
September	4.0	3.6	1.00	0.73
October	4.0	4.0	1.32	0.64
November	4.8	4.6	1.81	1.08
December	4.8	5.0	1.65	1.55
Average	3.9	3.9	1.24	0.84

TABLE 2

Raw Water

Predominating odor

MONTH	Oily Hot	Oily Cold	Gasoline Hot	Gasoline Cold	Vegetable Hot	Vegetable Cold	Rusty Hot	Rusty Cold	Sewage Hot	Sewage Cold	Disagreeable Hot	Disagreeable Cold	Tarry Hot	Tarry Cold	Fishy Hot	Fishy Cold
	PER CENT OF TIME WHEN PREDOMINATING ODOR WAS															
January	25	78	0	18	7	—	19	—	30	—	15	—	4	4	—	—
February	43	100	—	—	—	—	9	—	48	—	—	—	—	—	—	—
March	32	88	8	0	—	—	—	—	64	12	—	—	—	—	—	—
April	4	58	—	19	—	—	11	—	58	19	19	4	—	—	—	—
May	4	58	—	27	—	—	46	7	46	8	—	—	4	—	—	—
June	4	72	—	20	—	—	24	—	64	8	—	—	—	—	8	—
July	4	54	—	11	4	—	42	31	50	4	—	—	—	—	—	—
August	4	96	—	4	—	—	22	—	63	—	—	—	—	—	—	—
September	—	100	—	—	—	—	—	—	100	—	—	—	—	—	—	—
October	19	100	—	—	—	—	7	—	74	—	—	—	—	—	—	—
November	—	100	—	—	—	—	33	—	67	—	—	—	—	—	—	—
December	55	91	—	—	—	—	9	—	36	9	—	—	—	—	—	—

of self purification exert a very beneficial effect, but in spite of this the water at Chester still contains objectionable odors and tastes. Summaries of the intensities and of the predominating types of odor are given in tables 1 and 2. It will be noted that the intensity is greater during the cold months. Another interesting feature is that a sample of water giving an oily cold odor develops a musty odor

TABLE 3

Activated carbon experiment 1929

Sanitary analyses of filter plant effluent and effluent carbon filter no. 5

CHARACTERISTIC	PARTS PER MILLION	
	Filter effluent	Effluent
	Laboratory tap	No. 5 carbon filter "Darco"
Serial number	S-13983	S-13984
Date of collection	10/16/29	
Date of examination	10/22/29	
Cold odor—20°C	3 Musty, earthy	1 Aromatic
Hot odor—90°C	3 Arom., musty	1 Aromatic
Turbidity—silica standard	0.0	0.0
Color—Platinum standard	5.0	0.0
Oxygen consumed	2.5	2.2
Nitrogen as free ammonia	0.278	0.006
Nitrogen as albuminoid ammonia—total	0.124	0.084
Nitrogen as nitrites	0.015	0.003
Nitrogen as nitrates	0.800	0.800
Chlorine	7.0	10.0
Alkalinity	34.0	37.0
Hardness, by soap method	77.1	80.0
Hydrogen ion concentration, pH	6.6	6.7
Iron	0.10	0.10
Residue on evaporation—total	170.0	170.0
Mineral residue—total	125.0	120.0

when heated. This is probably due to the fact that heating removes certain volatile odors and this permits the detection of other underlying odors of a different character which are classified as "musty."

PRELIMINARY PURIFICATION

In all but one of the experiments the water applied to the carbon filters had been purified by passage through a complete modern

rapid sand filter plant employing the following processes in the order named:

1. Pre-chlorination sufficient to produce a residual of about 0.5 p.p.m. chlorine.
2. Treatment with alum and lime to produce coagulation.
3. Cascade aeration.
4. Sedimentation for about 3 hours.
5. Filtration through sand.
6. Secondary lime treatment for the prevention of corrosion.
7. Secondary chlorination.

TABLE 4

Plant treated water

Predominating odor of water

MONTH	PER CENT OF TIME WHEN PREDOMINATING ODOR WAS																			
	Oily		Gasoline		Musty		Sewage		Medicinal		Aromatic		Woody		Vegetable		Misc.		No odor	
	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold
January	7	37	0	4	37	4	15	7	11	0	0	0	11	0	4	0	4	0	11	48
February	13	44	0	0	74	17	0	4	0	0	0	0	0	0	0	0	9	0	4	22
March	0	48	0	0	84	4	0	4	4	0	4	12	0	0	0	0	0	0	8	24
April	4	30	0	4	80	25	0	0	0	0	0	0	0	0	4	0	0	0	12	41
May	4	28	0	0	75	11	3	14	7	0	0	0	0	0	0	0	0	0	11	47
June	0	0	0	0	91	30	0	26	0	0	0	0	0	0	0	0	5	0	4	44
July	0	0	0	0	78	27	0	0	0	0	0	0	0	0	0	0	0	0	22	73
August	0	3	0	0	81	19	0	0	0	0	0	0	6	0	0	0	0	0	13	78
September	0	0	0	0	100	62	0	0	0	0	0	0	0	5	0	0	0	9	0	24
October	0	12	0	0	96	48	0	0	0	0	0	0	0	0	0	0	0	0	4	40
November	0	0	0	8	92	72	8	8	0	0	0	0	0	0	0	0	0	0	4	12
December	20	90	0	5	75	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5

The effluent of this plant was free from turbidity at all times and contained a residual chlorine content of 0.2 to 0.4 p.p.m. The chemical characteristics of this water are indicated by the analytical results in table 3.

Table 4 shows the predominating odors in the treated water and the frequency of their occurrence. In table 1 the average intensity of the odors is given and the detailed results are graphically depicted on figure 3. The reductions in the intensity of raw water odor effected by the purification plant were 68 percent for hot odor and 78 percent for cold odor, based on the averages.

METHODS OF ODOR DETERMINATION

Due to the changing character of the tastes and odors and the varying mixtures of the substances producing them, no simple analytical method has been devised for accurately measuring their quantities. In the absence of a definite parameter it was necessary to fall back on the methods for odors described in Standard Methods of Water Analysis. The limitations of these methods are known to all, since they depend on the judgment of the observer and his ability to detect and evaluate odors. Fortunately we were not compelled to rely on one observer alone, many observations were checked by another observer and it was frequently possible to conduct blindfold tests with from 3 to 5 trained observers participating. Doubtless a number of irregularities occurred, but every effort was made to render a fair judgment on all samples examined.

TABLE 5

Summary of results for loss of head and rate of flow

FILTER NUMBER	RATE	LOSS OF HEAD FEET		LENGTH OF RUN IN DAYS BETWEEN WASHINGS			MATERIAL
		Initial	Final	Average	Maximum	Minimum	
	Gal./sq. ft./min.						
1	2	0.20	3.5	48	78	26	Nuchar
2	4	0.57	6.8	28	29	26	Darco*
3	2	0.47	4.4	23	39	10	Nuchar
4	3†	1.10	3.2	26	42	10	Nuchar
5 (1st period)	2	1.10	4.8	3	6	0.3	Darco
5 (2nd period)	2	0.6	3.8	28	40	22	Darco
6 (Settled water)	2	0.5	5.4	4	6	2	Minchar
7	2	0.9	—	Indeterminate			Nuchar
8	3	0.6	—	Indeterminate			Darco

* Preliminary run with Nuchar not included.

† Preliminary run at 4 gallon rate not included.

The technique for hot and cold odor was carried out according to Standard Methods, but a slightly different system of evaluating the odors was employed. Standard Methods use numbers from 0 to 4 to express a gradual increase of odor and then jumps to 5 for a water whose odor is such as to make it unfit for drinking. We have used the same numerals, but have tried to divide the scale of odors from 0 to 5 into even steps. The general relation between the two methods

is demonstrated in figure 1. This curve is not constructed from actual observation, but is empirical and is given merely to illustrate the comparison.

Observations of hot and cold odor and cold taste were made on all samples of treated water and carbon filter effluents. Observations

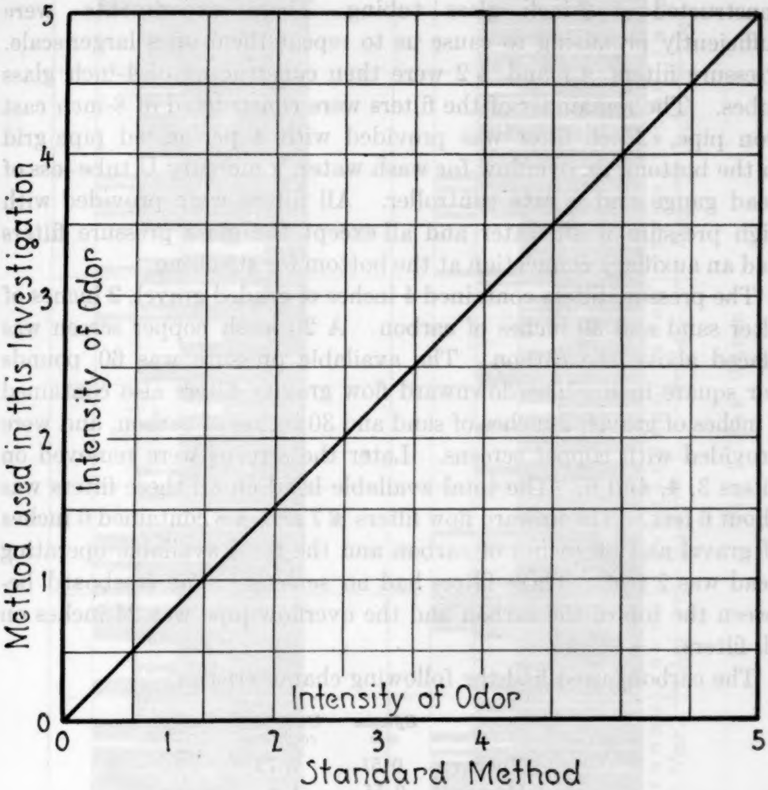

FIG. 1. COMPARISON OF INTENSITIES OF ODOR IN WATER AS DETERMINED BY STANDARD METHODS AND METHODS USED IN THIS INVESTIGATION (AN APPROXIMATION ONLY)

of taste were not made on the raw river water. In general, there is a close relation between odor and taste, but our results indicate that the intensity of the taste is usually less than that of the odor. Hot odors are generally of greater intensity than cold odors. For the purpose of judging the efficiency of carbon it is felt that the results

for odor are all that is necessary and for this reason, and in order to avoid a multiplicity of data, the results of observations for taste have been omitted.

DESCRIPTION OF EXPERIMENTAL FILTERS

In the beginning a number of experiments were run using filters constructed of 2-inch glass tubing. These experiments were sufficiently promising to cause us to repeat them on a larger scale. Pressure filters #1 and #2 were then constructed of 4-inch glass tubes. The remainder of the filters were constructed of 8-inch cast iron pipe. Each filter was provided with a perforated pipe grid in the bottom, an overflow for wash water, a mercury U tube loss of head gauge and a rate controller. All filters were provided with high pressure wash water and all except the glass pressure filters had an auxiliary connection at the bottom for steaming.

The pressure filters contained 4 inches of graded gravel, 2 inches of filter sand and 30 inches of carbon. A 20 mesh copper screen was placed above the carbon. The available pressure was 60 pounds per square inch. The downward flow gravity filters also contained 4 inches of gravel, 2 inches of sand and 30 inches of carbon, and were provided with copper screens. Later the screens were removed on filters 3, 4, and 6. The total available head on all these filters was about 6 feet. The upward flow filters #7 and #8 contained 6 inches of gravel and 36 inches of carbon and the total available operating head was 2 feet. These filters had no screens. The freeboard between the top of the carbon and the overflow pipe was 24 inches on all filters.

The carbons used had the following characteristics:

	Effective size	*Uniformity coefficient*
Nuchar:	0.51	3.72
Darco:	0.55	1.8
Minchar:	No analysis available.	

THE OPERATION OF THE EXPERIMENTAL FILTERS

In table 3 a sanitary analysis of the effluent of Darco filter #5 is compared with a similar analysis of the filter plant effluent. The carbon effected a reduction in the nitrogenous matter as shown by the free and albuminoid ammonia. The absorption of carbonaceous organic matter, shown by the oxygen consumed, is not so marked. The various mineral constituents remain unchanged by the carbon.

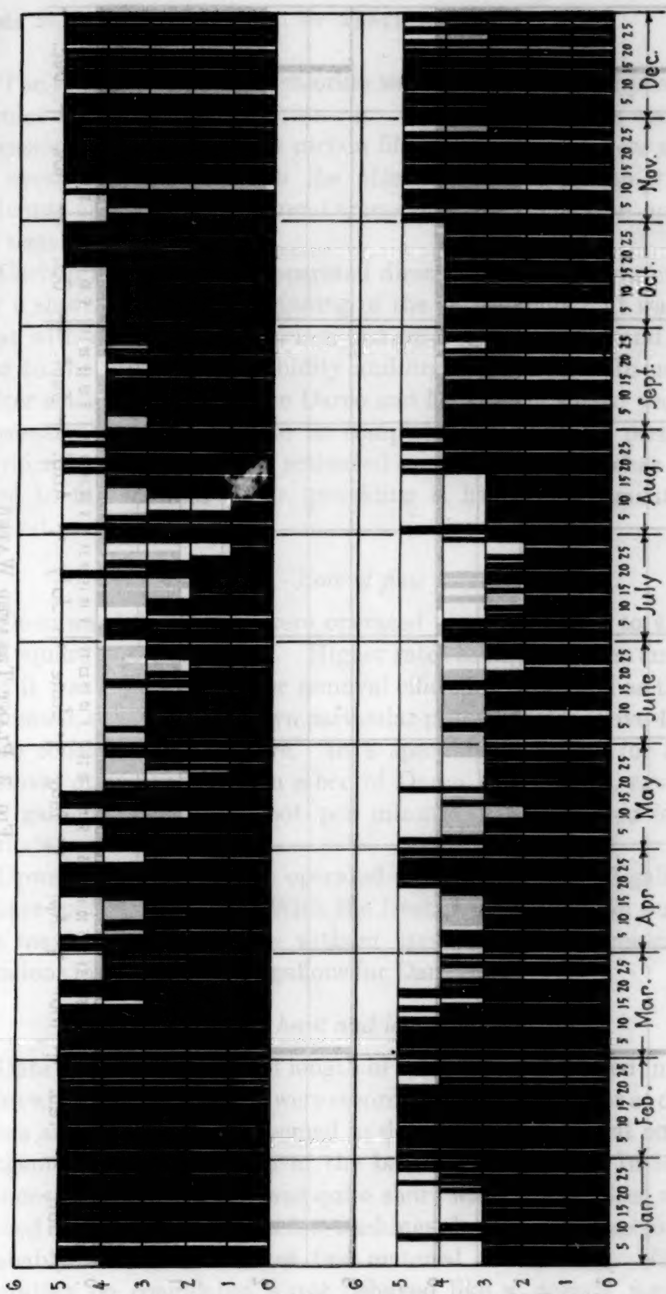

FIG. 2. RAW WATER

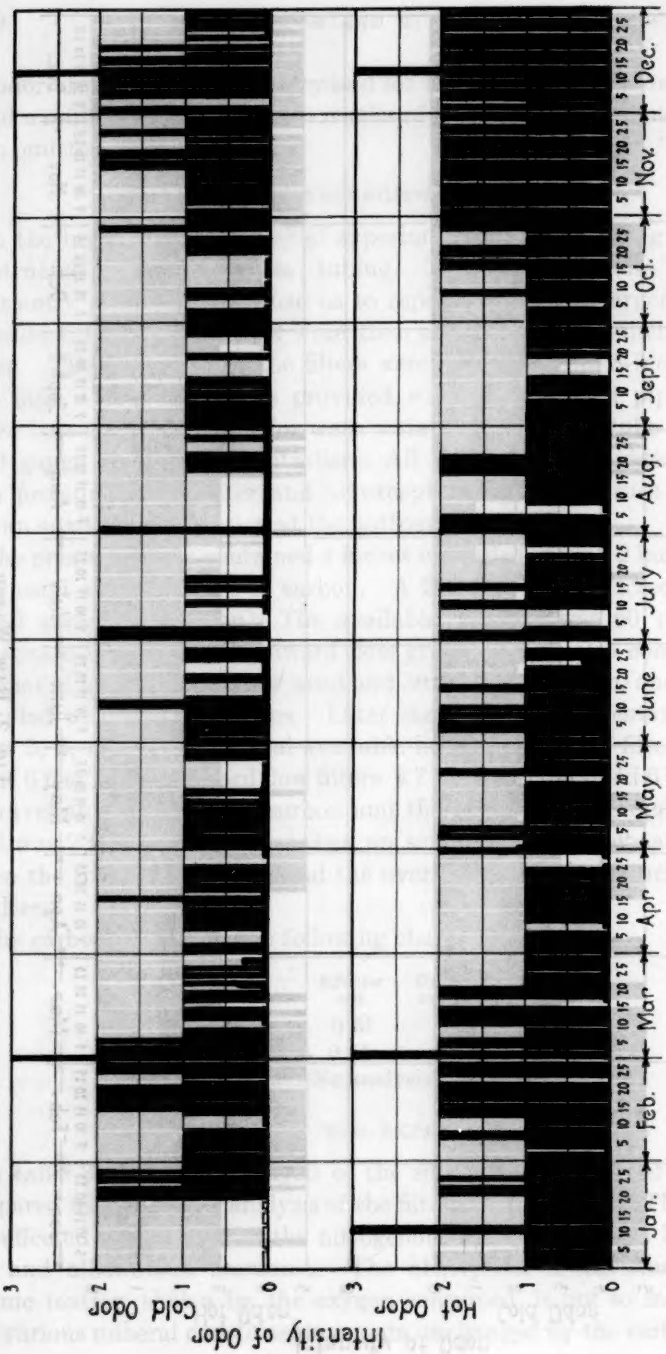

FIG. 3. PLANT TREATED WATER

The removal of residual chlorine was not made the subject of particular study in these experiments. Ortho-tolidine tests were made occasionally on the various carbon filter effluents and were negative in every case except with the Minchar filters #4A an #6. The effluents of these filters showed traces of residual chlorine on almost all tests.

Carbon filters were not operated directly on the raw water except for a short time at the beginning of the experiments. It was found that with raw water the carbon bed soon became dirty and clogged due to the presence of turbidity and organic matter. In using the softer activated carbons like Darco and Nuchar on turbid water it is necessary for the water to be completely clarified by preliminary purification. The harder activated carbons, like Minchar can be used to filter turbid water, providing it has been coagulated and settled.

Rate of flow

Downward flow filters were operated at rates from 2 to 4 gallons per square foot per minute. Higher rates could have been employed, but it was found that odor removal efficiency decreased as the rates increased, so that for our own particular problem rates above 4 gallons were considered prohibitive. In a special experiment for chlorine removal only, conducted in a bed of Darco 16 feet deep, rates up to 135 gallons per square foot per minute were employed for short periods.

Upward flow filters were operated at rates from 2 to 3 gallons per square foot per minute. With the freeboard available in our filters the maximum upward rate without appreciable loss of material was 2 gallons for Nuchar and 3 gallons for Darco.

Loss of head and length of runs

Data on loss of head and length of runs are summarized in table 5. Somewhat irregular figures were recorded on the same filter at different times and these features seemed to depend to some extent on the arrangement of the particles of the bed after washing. In some instances the length of run was quite short when a new filter was first placed in service but after a few washings the run increased to normal probably because of loss of fine material on washing. Filter #6 operating on coagulated water behaved like a normal rapid sand filter as regards loss of head and length of run.

Washing

Upward flow filters do not require washing under normal conditions. However, after about 5 months of operation some clogging was noted in Filters 7 and 8 and was found to be due to accumulations of material in the gravel. This condition was practically eliminated by alternate flooding and releasing the water in a downward direction. Similar accumulations gathered in the upper portion of the carbon on the downward flow units and resisted efforts to remove them with wash water. These accumulations may be attributed to iron from the pipe lines and possibly to particles of lime from the secondary lime treatment.

The first of the carbon filters were equipped with 20 mesh copper screens to hold the carbon down when washing. These screens were found to interfere with washing by preventing the expansion of material and were later removed. While the screens were in place a rate of wash of 15 gallons per square foot per minute was used and this was the rate employed on the Minchar filters at all times. After the removal of the screens a 4 gallons per square foot per minute rate of wash was employed on all units except the Minchar.

Regeneration

Experiments have demonstrated that when the carbon begins to lose its efficiency for removing odors it can be regenerated, at least partially, by the use of steam or hot air. Since steam under pressure was readily available it was used exclusively in the practical experiments under discussion. The method was simply to drain the filter and apply steam slowly into the under drains until the whole mass was heated to boiling temperature where it was maintained until the steam rising from the top of the filter was relatively free from odor. The time required to acomplish this was from 20 to 30 minutes and in some cases a filter was steamed for two such periods with a normal wash between steamings. It was very interesting to stand above the filters while they were being steamed and to observe the odors which were driven off. During the earlier part of the process the lighter hydrocarbons and other volatile materials predominated later giving way to the odor of heavier oils and unpleasant organic material. The results indicate that the ability of the filter to remove odors is restored, to a great extent, by this treatment. It appears, however, that the period of effective operation may decrease after each regeneration and the presumption is that a point would ulti-

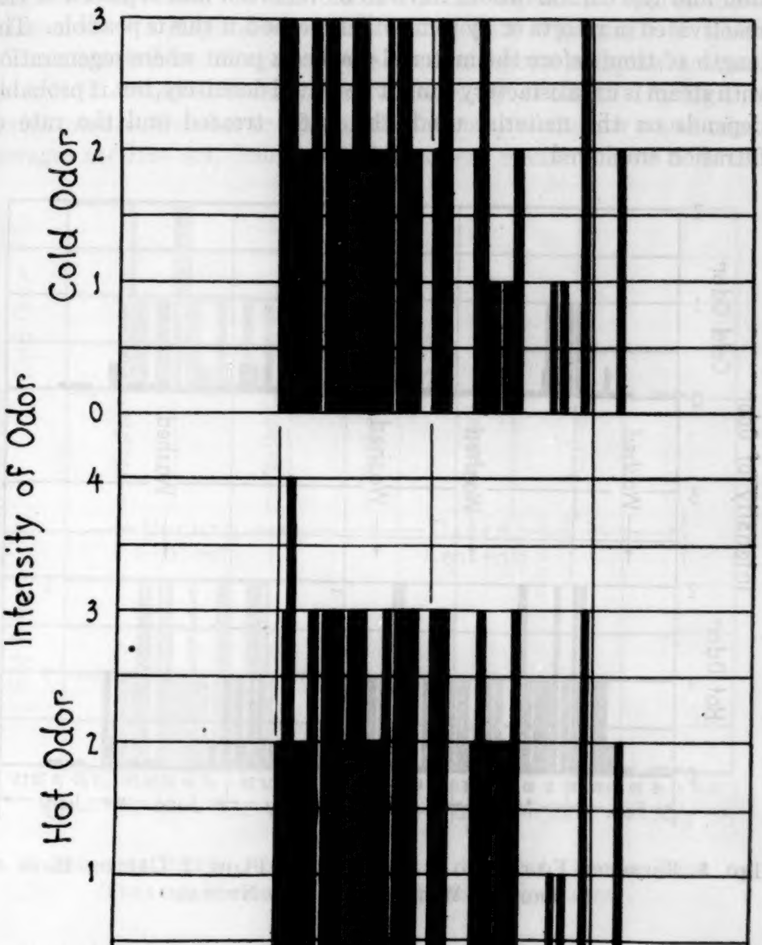

FIG. 4. PLANT SETTLED WATER AS APPLIED TO GRAVITY FILTER NO. 6

mately be reached when nothing would be gained by further regeneration and the carbon would have to be removed and replaced or else reactivated in retorts or by some other method, if this is possible. The length of time before the material reaches a point where regeneration with steam is unsatisfactory cannot be stated definitely, but it probably depends on the material used, the water treated and the rate of filtration employed.

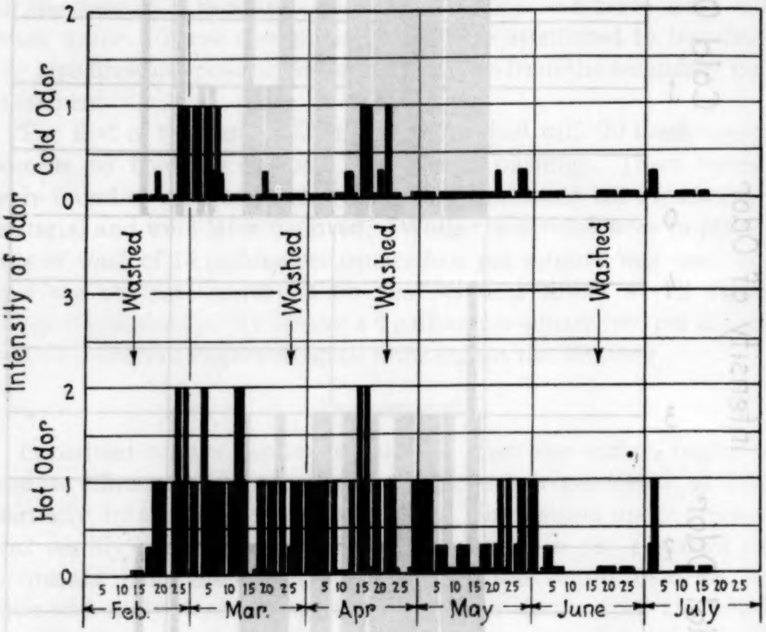

FIG. 5. PRESSURE FILTER NO. 1. DOWNWARD FLOW, 2 GALLON RATE ON TREATED WATER, 30 INCHES NUCHAR

Experimental results

The basic data on the operation of the various experimental filters are voluminous and will not be presented here in detail. Charts have been prepared, however, showing graphically the intensity of odor in the raw water, in the purification plant effluent and in the effluents of each carbon filter during their periods of operation. In the conduct of our work we have had occasion to plot the observed odor intensities as curves and from these it appears that an odor designated as Trace has a numerical value of about 0.3. Therefore,

in preparing the charts the designation "Trace" has been arbitrarily assigned this value. In the discussion the adjective "appreciable" is assumed to correspond with an intensity of 1.0 or greater.

The most striking thing about the data on the raw and plant treated water is the seasonal variation in the intensity of odor. During the winter months, October to March, the intensity of the raw water odor averages are Hot 4.4, Cold 4.6 with frequent maximums of 5. while

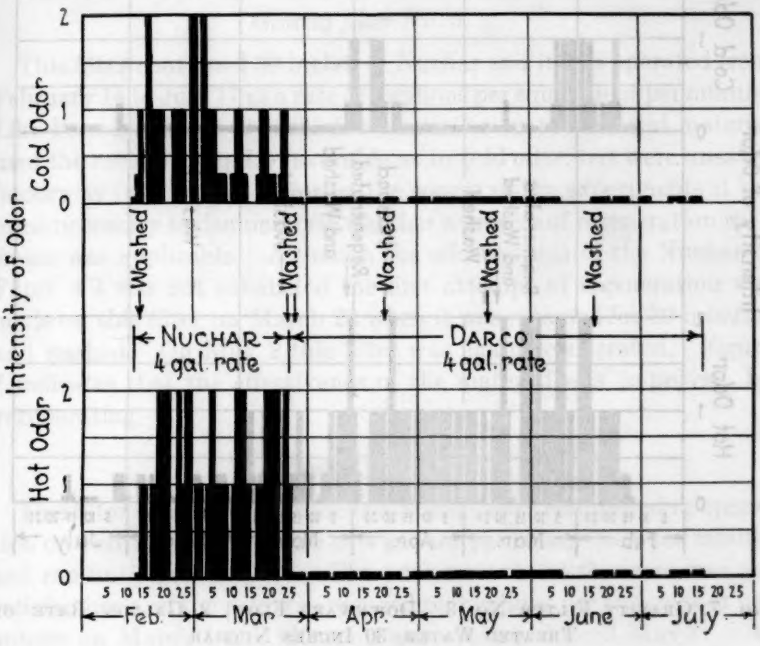

FIG. 6. PRESSURE FILTER NO. 2. DOWNWARD FLOW, 4 GALLON RATE ON TREATED WATER, 30 INCHES NUCHAR AND DARCO

the treated water averages are Hot 1.44, Cold 1.26. During the warmer months, April to September, the raw water averages are Hot 3.3, Cold 3.3, while the treated water averages are Hot 1.04, Cold 0.53. On the raw water the predominating cold odor is oily while the predominating hot odor is sewage or musty. On the treated water the predominating hot and cold odor is musty, although during the summer months, notably July and August, there was no odor in the plant treated water for a relatively large portion of the time particularly in the cold.

It is readily apparent that this seasonal variation in the intensity of odor in the water applied to the carbon filters affected their efficiency for odor removal. The real test of the efficiency of the carbon came during the winter months. This must be borne in mind when studying the record of operation of the various units.

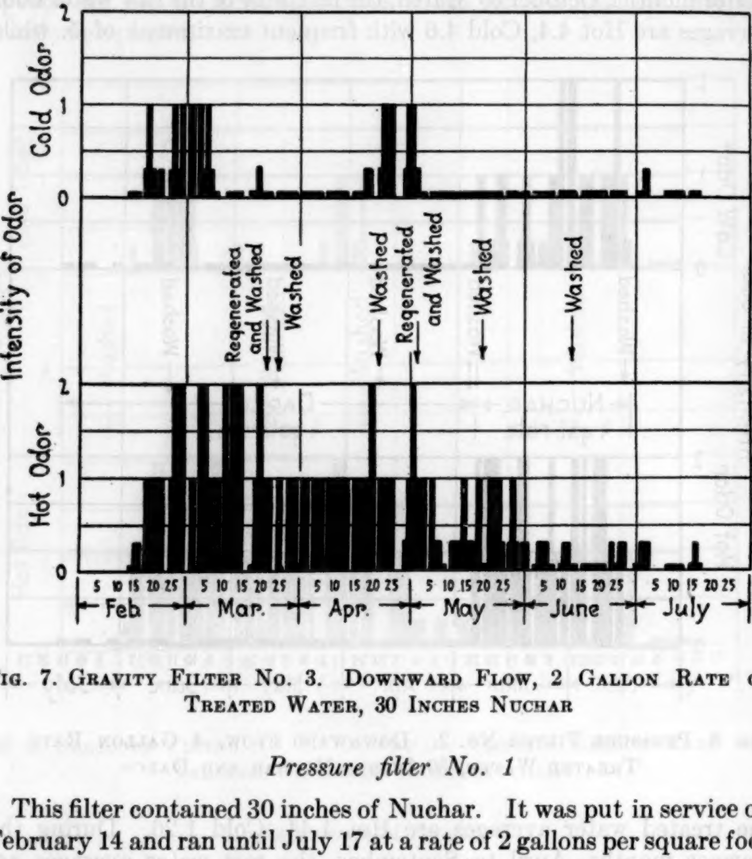

FIG. 7. GRAVITY FILTER NO. 3. DOWNWARD FLOW, 2 GALLON RATE ON TREATED WATER, 30 INCHES NUCHAR

Pressure filter No. 1

This filter contained 30 inches of Nuchar. It was put in service on February 14 and ran until July 17 at a rate of 2 gallons per square foot per minute operating on treated water. The effluent of this filter was fairly satisfactory as regards cold odor, but was unsatisfactory as regards hot odor, the latter being appreciably more than 80 percent of the time in March and April.

Pressure filter No. 2

This filter was first filled with 30 inches of Nuchar and was operated from February 14 until March 26 on treated water at a rate of

4 gallons per square foot per minute. The Nuchar was then replaced with 30 inches of Darco and the run continued until July 17. The contrast between the efficiency of the two materials is shown in figure 6. The effluent with Nuchar showed an appreciable odor 87 percent of the time while with Darco the odor was uniformly 0. Even though the applied water was somewhat better during the Darco run the contrast is significant.

Gravity filter No. 3

This filter contained 30 inches of Nuchar and it was operated from February 14 to July 17 at a rate of 2 gallons per square foot per minute. Like Pressure Filter #1 which was similar as to rate and material used the results are quite favorable as to cold odor, but were unsatisfactory as to hot odor. During the course of the experiments it became necessary to demonstrate whether a process of regeneration with steam was applicable. Although the effectiveness of the Nuchar in Filter #3 was not exhausted the first attempt at regeneration was made on this filter on March 22 when it was steamed for 30 minutes and washed. On May 2 this filter was again regenerated. Figure 7 indicates that the effectivenes of the material was improved by regenerating.

Gravity filter No. 4

This filter contained 30 inches of Nuchar and was placed in operation on February 14 at a rate of 4 gallons per square foot per minute and ran until February 28. The odor removal at this rate was unsatisfactory and the rate was reduced to 3 gallons per square foot per minute on March 1 and filtration was continued until May 31. At this time the Nuchar was removed and replaced with 30 inches of Minchar and the filter was redesignated as #4A. Comparing the results of Filter #4 at 4 and 3 gallon rates with Filter #3 at a 2 gallon rate, it will be seen that the odor removal was more satisfactory at the 2 gallon rate, the difference between the results at 4 gallon and 2 gallon being quite marked.

Filter No. 4A

This was #4 Filter after the Nuchar had been replaced with Minchar. The filter ran from June 1 until July 17 at a rate of 4 gallons per square foot per minute. The Minchar did not effect satisfactory odor removal, although there is a noticeable reduction as shown in figure 8.

Filter No. 5

This filter was first filled with 30 inches of fine Darco and placed in service on February 14 at a rate of 2 gallons per square foot per minute operating on plant treated water. The first filter runs were short and on March 12 the fine Darco was replaced with a coarser grade. From this time on the mechanical operation was entirely satisfactory.

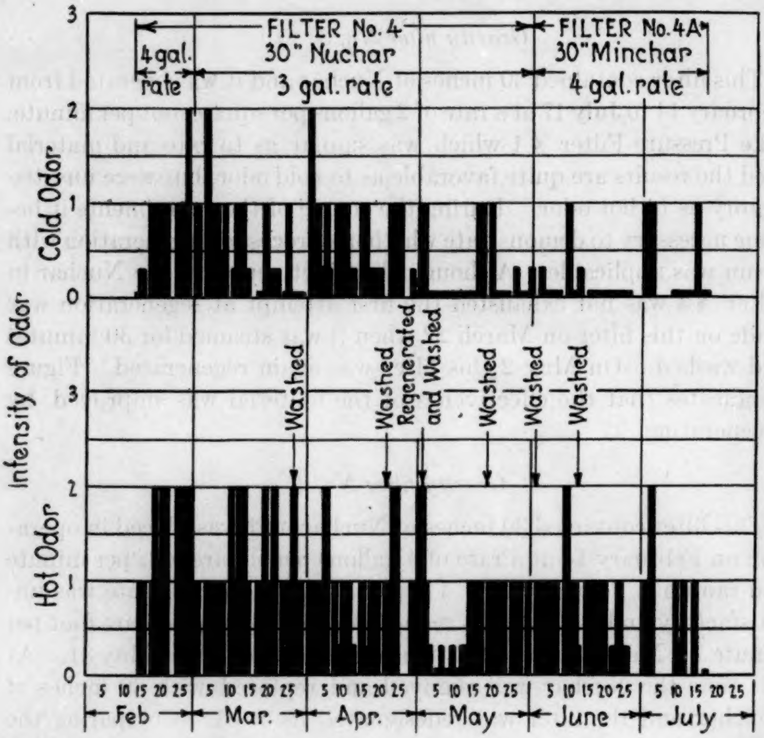

FIG. 8. GRAVITY FILTERS NOS. 4 AND 4-A. DOWNWARD FLOW, 4 GALLON RATE ON TREATED WATER, 30 INCHES NUCHAR AND MINCHAR

The efficiency of this material for odor removal was nothing short of remarkable. An appreciable odor was observed on only eight occasions during the entire period covered by this report and in no case was the intensity greater than 1. Going beyond the period covered by this report it may be stated that early in February, 1930, the effluent of this filter had deteriorated to a point where an appreciable odor was apparent at all times. The filter was taken out of service for a short

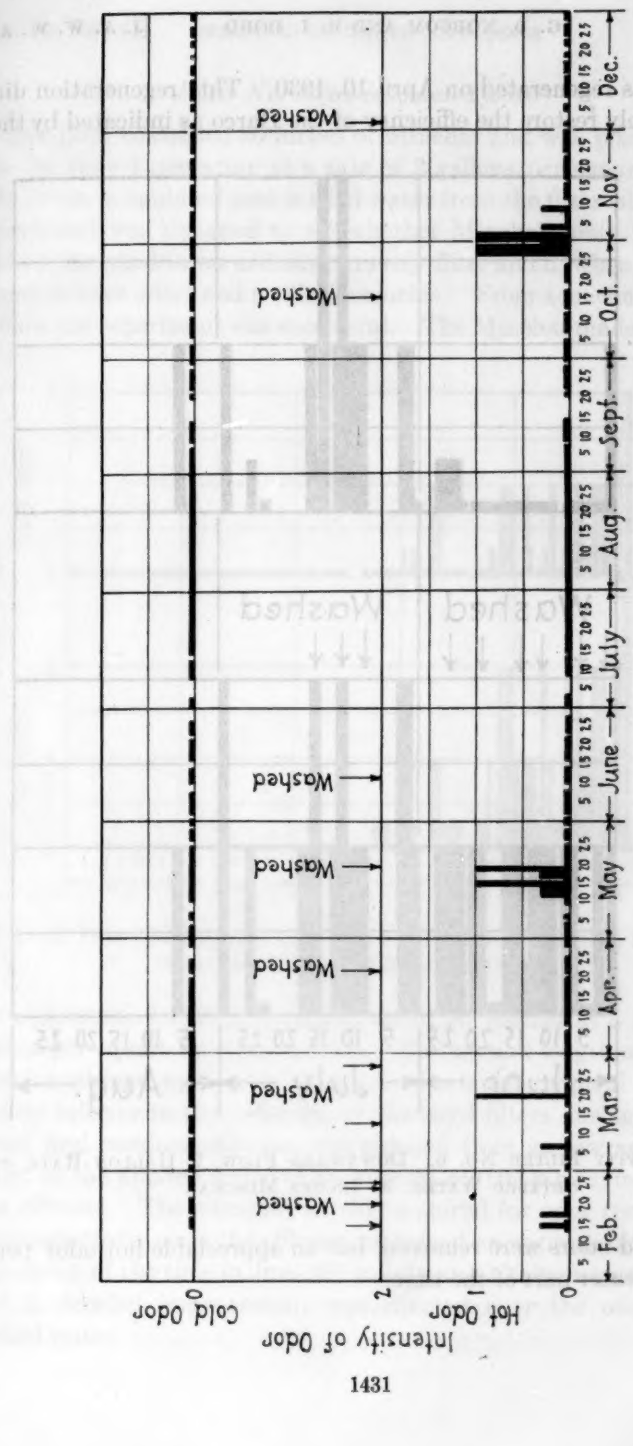

FIG. 9. GRAVITY FILTER NO. 5. DOWNWARD FLOW, 2 GALLON RATE ON TREATED WATER, 30 INCHES DARCO

time and was regenerated on April 10, 1930. This regeneration did not completely restore the efficiency of the Darco as indicated by the

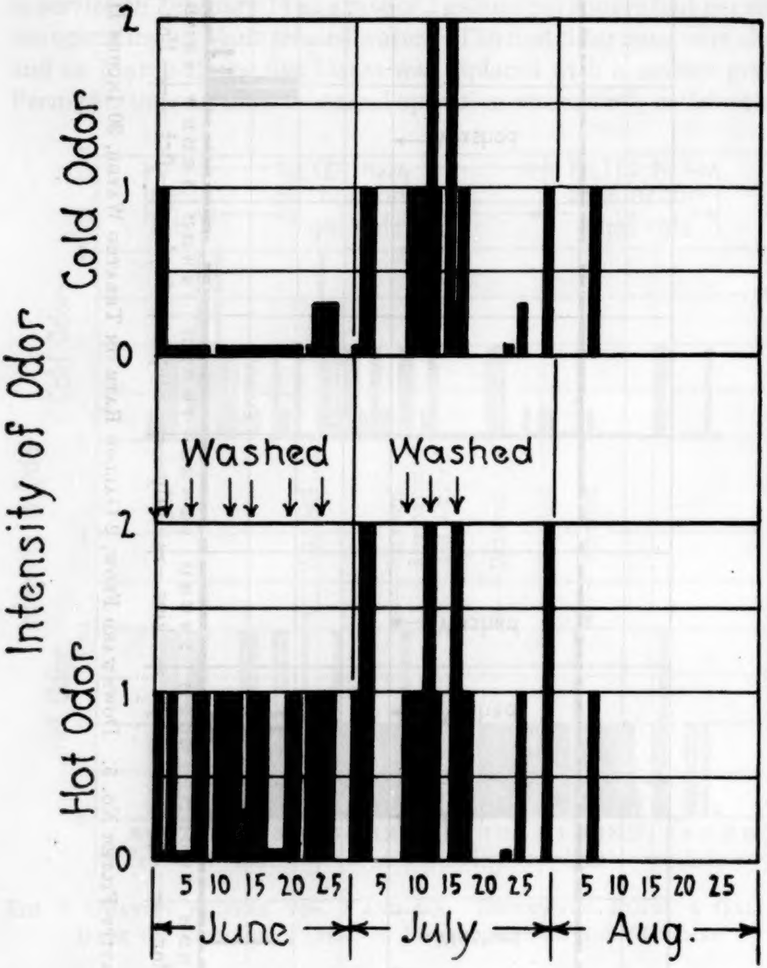

FIG. 10. GRAVITY FILTER NO. 6. DOWNWARD FLOW, 2 GALLON RATE ON SETTLED WATER, 30 INCHES MINCHAR

fact that cold odors were removed, but an appreciable hot odor persisted the greater part of the time.

Filter No. 6 (on coagulated water)

This filter contained 30 inches of Minchar and was placed in service on June 1 operating at a rate of 2 gallons per square foot per minute on coagulated and settled water from the filter plant. This experiment was designed to see whether Minchar could be used to replace the sand in an ordinary gravity filter and if, when so used, it would remove odors and residual chlorine. From a mechanical point of view the experiment was successful. The Minchar made a satisfac-

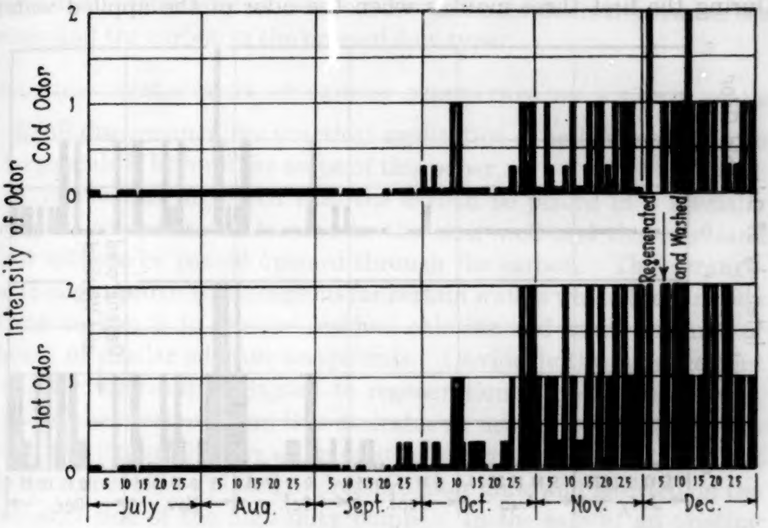

FIG. 11. GRAVITY FILTER NO. 7. UPWARD FLOW, 2 GALLON RATE ON TREATED WATER, 30 INCHES NUCHAR

tory substitute for filter sand and could be washed at a rate of 15 gallons per square foot per minute. The normal length of runs between washings was about 4 days. Bacterial removal was only slightly inferior to that effected by the sand filters during the same period and residual chlorine was reduced from an average of 0.50 p.p.m. in the applied water to an average of 0.03 p.p.m. in the Minchar effluent. The efficiency of this material for odor removal was not satisfactory, since the effluent contained an appreciable hot odor 64 percent of the time in June, 60 in July and 100 in August. However, a decided improvement was effected over the odor of the applied water.

Filter No. 7 (upward flow)

Benefiting from the experiences of others and with a view to designing a filter which would not require washing it was decided in June to make some observations on upward flow filters. Filter #7 was filled with 36 inches of Nuchar and operated until the end of the period covered by this paper (December 31, 1929). It was determined by experiment that this filter as constructed could not be operated at a rate exceeding 2 gallons per square foot per minute without loss of material and this was the rate employed throughout the run. During the first three months when the odor of the applied water

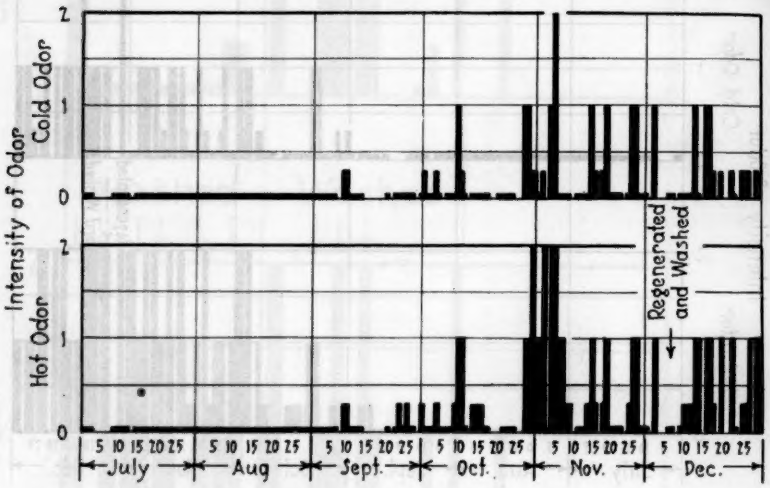

FIG. 12. GRAVITY FILTER NO. 8. UPWARD FLOW, 3 GALLON RATE ON TREATED WATER, 36 INCHES DARCO

was close to the minimum, the results were entirely satisfactory. The efficiency of the filter began to fail in October and from November 1 on the results were unsatisfactory. Regeneration was tried on December 6, but was of no apparent benefit indicating that this type of filter was unable to cope satisfactorily with the increased load.

Filter No. 8 (upward flow)

This filter contained 36 inches Darco and was started July 1. It was still in operation at the end of 1929. The rate employed was 3 gallons per square foot per minute, the maximum possible in this filter as determined by experiment. While the results of operation

were superior to those obtained with #7, they are not satisfactory when judged by a standard requiring the continuous production of an effluent with odor less than 1. The results compare unfavorably with those secured in Filter #5, containing Darco at a 2 gallon rate, downward flow. The poor showing of Filter #8 as compared with Filter #5 may be due to some extent to the difference in rate. However, it appears logical to conclude from the performance of Filter #7 and #8 that upward flow is somewhat less efficient in odor removal on this particular water during the winter months than is downward flow. This may be due to a less intimate contact between the water and the carbon in the upward flow type.

PRACTICAL APPLICATION OF CARBON FILTRATION ON A LARGE SCALE

A full discussion of the practical application of activated carbon on a large scale is beyond the scope of this paper.

1. Baylis has suggested that the carbon be placed in a specially designed compartment located in the clear well and that the sand filter effluent be passed upward through the carbon. This arrangement might prove advantageous for certain waters where the function of the carbon is to remove residual chlorine and small amounts of phenol or similar odorous compounds. Obviously this arrangement could not be readily adapted to regeneration in place with steam.

2. In those cases where it is desirable or necessary to employ carbon filtration on the site of an existing gravity type filtration plant the carbon could be placed in pressure filter units and inserted on the discharge side of the high duty pumps. In the case of an existing pressure filter plant the carbon pressure units could be placed in series following the sand units. Either downward or upward flow types might be used with this arrangement. The danger of particles of carbon being carried into the distribution system would be prevented with downward flow type by the layer of sand beneath the carbon. However it appears that this danger could be minimized and perhaps eliminated in the upward flow type by placing the outlet at a point sufficiently above the level of carbon in the filter.

3. In those cases where water is pumped from a filtration plant to an open storage reservoir before passing into the distribution system the carbon filter plant could be located at the reservoir. In this case the carbon units might be either open or pressure type, operated on either the upward or downward flow principle.

In any case, the carbon units should be so designed as to permit the

application of steam through the under drains in sufficient quantity to maintain a temperature of 212°F. for a half hour or longer. A suitable vent should be provided on closed type units to permit the escape of vapors during regeneration. A steam generating plant of proper size and suitable wash water facilities would be required.

SUMMARY

1. During the year 1929 a number of experiments have been conducted on a river water containing objectionable odors with a view to producing a drinking water which would at all times be free from appreciable odor or taste.

2. In all except one experiment the raw water was purified by passage through a rapid sand filter plant before being applied to the carbon filters. In the remaining experiment coagulation basin effluent was applied.

3. Comparing the respective efficiencies of the different materials used for odor removal at a given rate of filtration, these experiments indicate that Darco is superior to either Nuchar or Minchar. The difference between the last two is not so marked, but the advantage is definitely in favor of Nuchar.

4. The harder materials like Minchar, which also have a lower carbon content, have an advantage in that they can be used in place of sand with coagulated water. The softer carbons like Darco and Nuchar are not applicable to direct filtration of raw or coagulated water but should be used on waters from which turbidity and organic matter have been removed.

5. On the particular water studied in these experiments a rate of filtration of 2 gallons per square foot per minute gave best results. Lower rates were not tried, but might have given better results on Nuchar and Minchar. Higher rates tended toward a decrease in efficiency.

6. It is possible to operate carbon filters with either upward or downward flow. Where conditions are favorable upward flow is to be preferred because head losses are small and washing is practically eliminated. On the other hand our experiments indicate that odor removal is not as good with upward as with downward flow even though a thicker carbon bed is used.

7. Under the conditions of this experiment it appears that a 30-inch bed of Darco operating on purified water at a 2 gallon rate will remove all appreciable odor for about one year without regeneration.

8. The passage of steam through beds of Darco or Nuchar so as to maintain a boiling temperature for about a half hour will remove a quantity of the substances which have been absorbed by the carbon. It is probable that this process does not amount to complete regeneration of the material and that ultimately the capacity of the carbon to remove odor and taste will become impaired to such an extent as to require its removal and replacement with new or completely regenerated material.

9. Objectionable odors in water due to minute quantities of industrial waste can be removed by means of activated carbon. With the new and improved carbons which are being developed it is reasonable to anticipate that even better results will be secured in the future than those reported in this paper.

ACKNOWLEDGMENT

The work described in this paper was carried out under the general direction of T. H. Wiggin, Chief Engineer, Public Works Engineering Corporation and Robert Spurr Weston, of Weston and Sampson, Consulting Sanitary Engineer.

FURTHER OBSERVATIONS ON THE USE OF ACTIVATED CARBON IN REMOVING OBJECTIONABLE TASTE AND ODORS FROM WATER[1]

By John R. Baylis[2]

In a recent article[3] the writer gave some of the characteristics of activated carbon, and experiments on its use in water treatment. The present brief discussion is more to bring the former article up to date than to present new material. The carbon longest in continuous use was put in service December 27, 1928, making about seventeen months up to May 1, 1930. As the material is still giving satisfactory service no information is available as to its probable life. If seventeen months was the life of the material it would be expensive for water treatment in municipal supplies, although not prohibitive. There is every indication, however, that the life will be much longer and that the cost per million gallons of treating the water in this manner will be well within what municipalities can afford to pay.

PROPOSED NAME FOR CARBON UNITS

It is proposed that beds of activated carbon be called "carbon adsorption beds," and the complete units "carbon units" and not carbon filters. They are not filters and should not be used for filtering purposes. Water needing clarification should be filtered before going to the carbon units. One essential feature of the carbon adsorption bed is that as much surface area of carbon as is possible should be exposed to the water. Regardless of how fine the granules may be, each particle itself must be porous so as to increase the surface area. The pores will become clogged if the water contains suspended matter and a much less area of the carbon will be exposed to the water. This is not saying the material cannot be used for a filter bed if of the proper size granules, but to do so would decrease the rate of adsorption. Other materials, such as sand, are very much cheaper for filter beds.

[1] Presented before the Water Purification Division, the St. Louis Convention, June 4, 1930.

[2] Physical Chemist, Bureau of Engineering, Chicago, Ill.

[3] Journal, June, 1929, page 787.

UNITS FOR CONDUCTING EXPERIMENTS

Experiments have been conducted on two size units. The larger size is about 3.56 feet in diameter, giving 10 square feet of area, and the smaller size is glass tubes about $1\frac{5}{8}$ inches in diameter. The larger size unit was described and illustrated in the article already mentioned.[3] It is just a small rapid sand filter tank with underdrains and a bed of graded gravel which is filled with active carbon instead of sand. Three hundred and sixty pounds of Hydrodarco (the trade name of the material manufactured for water works uses is Hydrodarco instead of Darco as used in the former paper) was placed in this unit, making a bed about 24 inches in thickness. About 20 pounds of the material has since been removed for testing purposes and for use in glass tube units. The bed is now about 23 inches in thickness.

The carbon unit is set below the level of the filters so that the filtered water can flow through it without having to be pumped. With this particular unit the water flows upward through the bed of carbon instead of downward as in the case for filter beds. It probably makes little difference which way the water flows just so long as it comes in contact with the carbon granules. In this particular case it was easier to operate with an upward flow.

The adsorption bed is washed by increasing the flow to a rate that suspends or partially suspends the carbon granules. It is evident, of course, that the water should be run to waste during the washing period. The rate of wash will depend on the material. The beds should not be expanded more than 50 to 60 percent during the washing period to avoid excessive loss of the carbon. For some carbons, the washing rate will not vary greatly from that used in washing sand beds, although this will depend on the size granules and their specific gravity. The frequency of wash will depend on the thoroughness of filtration prior to passing the water through the adsorption beds. With the water filtered perfectly clear, six months between washings will be sufficient when an upward flow is used. For downward flow, the loss of head may be the controlling factor. There can be only a certain maximum loss of head, which is provided for in the design, and when the loss reaches this point the beds should be washed. There is no building up the loss of head in the beds with an upward flow.

TABLE 1
Dechlorination with activated carbon

Carbon unit no. 8. Surface area 10 square feet

Carbon adsorption bed was 24 inches thick and contained 360 pounds (20 cubic feet) of Hydrodarco. Chlorinated filtered water passed through the bed in an upward direction at the rate of 2 gallons per square foot per minute unless otherwise stated. Unit put in service December 28, 1928. Pre-chlorinated water started March 11, 1929.

DATE	TEMPERATURE, °C.	RESIDUAL CHLORINE, P.P.M.		DATE	TEMPERATURE, °C.	RESIDUAL CHLORINE, P.P.M.	
		Applied water	Effluent carbon unit			Applied water	Effluent carbon unit
3-11-29	7.0	0.12	0.00	5-22-29	12.0	0.36	0.00 Tr.
19	8.0	0.05	0.00	25	12.0	0.30	0.00 Tr.
20	9.0	0.04	0.00	31	13.0	0.35	0.00 Tr.
22	6.0	0.12	0.00	6- 7-29	14.0	0.18	0.00 Tr.
23	5.0	1.44	0.00 Tr.	8	14.0	0.60	0.00 Tr.
25	6.0	0.30	0.00	10	14.0	0.48	0.00 Tr.
26	6.0	0.48	0.00	12	14.0	0.60	0.00 Tr.
27	8.0	0.18	0.00	13	14.0	0.55	0.00 Tr.
28	8.0	0.38	0.00	15	14.0	0.50	0.00 Tr.
29	9.0	0.36	0.00	19	15.0	0.40	0.00 Tr.
4- 2-29	8.0	1.14	0.00	20	15.0	0.35	0.00 Tr.
3	8.0	1.20	0.00	22	15.0	0.65	0.00 Tr.
4	9.0	0.90	0.00	24	15.0	0.85	0.02
5	9.0	0.54	0.00	25	15.0	1.10	0.02
9	9.0	0.36	0.00	26	16.0	0.95	0.02
10	10.0	0.24	0.00	27	16.0	0.95	0.00 Tr.
11	10.0	0.54	0.00	28	17.0	0.95	0.00 Tr.
12	9.0	0.67	0.00	7- 2-29	17.0	0.95	0.00 Tr.
13	8.0	0.70	0.00	3	18.0	0.50	0.00 Tr.
15	8.0	0.85	0.00	6	18.0	0.95	0.00 Tr.
16	10.0	0.95	0.00	8	15.0	0.95	0.00 Tr.
17	8.0	0.55	0.00	9	14.0	0.70	0.00 Tr.
19	9.0	0.55	0.00	10	15.0	0.54	0.00 Tr.
20	10.0	1.44	0.00	10	15.0	1.45	0.00
22	10.0	1.20	0.00	11	15.0	0.96	0.00 Tr.
23	11.0	1.20	0.00	12	15.0	1.20	0.00 Tr.
24	11.0	0.95	0.00	13	15.0	0.95	0.00 Tr.
25	11.0	1.10	0.00	15	18.0	0.72	0.00 Tr.
29	12.0	0.72	0.00	16	18.0	0.54	0.00 Tr.
5- 8-29	10.0	0.30	0.00	17	18.0	0.70	0.00 Tr.

TABLE 1—*Continued*

DATE	TEMPERATURE, °C.	RESIDUAL CHLORINE, P.P.M.		DATE	TEMPERATURE, °C.	RESIDUAL CHLORINE, P.P.M.	
		Applied water	Effluent carbon unit			Applied water	Effluent carbon unit
7-18-29	18.0	0.80	0.00 Tr.	8-31-29	21.0	0.96	0.02
19	19.0	0.85	0.00 Tr.	9- 3-29	22.0	0.84	0.06
22	19.0	0.55	0.00 Tr.	4	22.0	1.20	0.06
23	19.0	0.60	0.00 Tr.	5	22.0	1.08	0.02
24	19.0	0.60	0.00 Tr.	6	22.0	1.20	0.05
25	19.0	0.55	0.00 Tr.	9	21.0	1.08	0.04
26	20.0	0.70	0.02	10	22.0	0.96	0.02
27	19.0	1.40	0.04	11	20.0	1.20	0.02
29	20.0	0.85	0.04	12	20.0	1.08	0.06
30	20.0	1.00	0.02	13	20.0	0.96	0.04
31	20.0	0.70	0.01	14	19.0	1.08	0.04
8- 1-29	22.0	0.85	0.02	16	19.0	1.20	0.02
2	21.0	0.80	0.02	17	18.0	0.96	0.02
5	22.0	0.95	0.02	18	18.0	1.32	0.02
6	21.0	0.85	0.01	19	18.0	1.32	0.04
7	22.0	0.95	0.02	20	17.0	1.32	0.04
8	20.0	0.80	0.01	21	17.0	0.96	0.02
13	22.0	1.00	0.02	23	17.0	1.32	0.02
14	21.0	0.95	0.02	24	17.0	1.44	0.02
15	21.0	1.00	0.02	25	17.0	1.20	0.02
16	20.0	0.90		26	17.0	0.96	0.01
19	20.0	0.95	0.05	27	17.0	1.08	0.02
20	20.0	1.10	0.01	28	18.0	1.08	0.02
21	20.0	0.95	0.02	30	17.0	1.20	0.02
22	20.0	0.90	0.02	10- 1-29	17.0	1.20	0.02
23	21.0	0.95	0.01	2	17.0	1.20	0.02
24	21.0	0.90	0.02	3	17.0	1.32	0.02
26	21.0	0.95	0.01	4	16.0	1.20	0.02
27	21.0	0.95	0.02	5	15.0	1.08	0.01
28	21.0	1.40	0.02	7	15.0	1.20	0.02
29	21.0	1.68	0.04	8	15.0	1.44	0.02
30	21.0	0.96	0.01	9	15.0	1.08	0.02
				10	14.0	1.20	0.02
				11	15.0	1.68	0.04
				15	14.0	1.08	0.02

TABLE 1—*Continued*

DATE	TEMPERATURE, °C.	RESIDUAL CHLORINE, P.P.M. Applied water	Effluent carbon unit	DATE	TEMPERATURE, °C.	RESIDUAL CHLORINE, P.P.M. Applied water	Effluent carbon unit
10-16-29	15.0	1.20	0.02	12-10-29	0.5	1.32	0.04
17	15.0	1.08	0.02	11	0.4	1.32	0.04
19	14.0	1.20	0.02	12	0.4	1.44	0.04
21	14.0	1.08	0.02	13	0.4	1.44	0.04
22	14.0	0.96	0.02	17	0.5	1.08	0.02
24	12.0	1.32	0.02	18	0.6	0.96	0.04
25	10.0	1.44	0.04	19	0.5	0.96	0.02
28	10.0	1.20	0.02	20	0.4	1.08	0.04
29	10.0	1.32	0.02	23	0.4	1.20	0.04
30	10.0	1.08	0.02	24	0.4	1.20	0.04
31	10.0	1.20	0.02	26	0.4	1.44	0.04
11- 1-29	10.0	1.32	0.02	27	0.4	1.44	0.04
2	10.0	1.44	0.04	28	0.4	1.20	0.05
4	10.0	1.44	0.04	30	0.4	1.08	0.02
5	10.0	1.20	0.02	31	0.4	1.32	0.04
6	10.0	1.20	0.02	1- 2-30	0.4	1.20	0.04
7	10.0	1.32	0.02	3	0.4	1.08	0.04
8	10.0	1.20	0.02	6	0.4	0.96	0.04
9	10.0	1.08	0.02	7	0.4	0.96	0.04
13	9.0	1.32	0.01	8	0.4	1.32	0.05
18	8.0	1.32	0.02	9	0.4	1.08	0.04
19	8.0	1.44	0.04	10	0.4	0.96	0.04
20	8.0	1.32	0.04	11	0.4	0.96	0.04
21	8.0	1.56	0.04	13	0.4	1.08	0.04
22	7.0	1.68	0.04	14	0.3	0.96	0.04
25	5.0	1.20	0.02	15	0.3	0.96	0.04
26	5.0	1.68	0.04	16	0.3	1.08	0.04
27	5.0	1.32	0.04	17	0.3	0.96	0.04
29	3.0	1.20	0.04	20	0.3	1.08	0.04
30	2.0	1.32	0.04	21	0.3	1.32	0.05
12- 2-29	1.0	1.20	0.02	22	0.3	1.44	0.05
3	0.7	1.32	0.04	23	0.3	1.44	0.05
4	0.5	1.32	0.04	24	0.3	1.32	0.05
5	0.5	1.20	0.04	25	0.3	1.32	0.05
9	0.4	1.20	0.04	27	0.3	1.20	0.05

TABLE 1—*Concluded*

DATE	TEMPERATURE, °C.	RESIDUAL CHLORINE, P.P.M. Applied water	Effluent carbon unit	DATE	TEMPERATURE, °C.	RESIDUAL CHLORINE, P.P.M. Applied water	Effluent carbon unit
1-28-30	0.3	1.08	0.04	3-17-30	3.0	1.26	0.07
29	0.3	1.08	0.04	18	3.0	1.08	0.06
30	0.3	0.96	0.04	19	3.0	1.20	0.06
31	0.3	1.14	0.04	20	3.0	1.20	0.06
2- 3-30	0.3	1.14	0.04	21	3.0	1.26	0.07
4	0.3	1.20	0.05	24	3.0	1.02	0.05
5	0.3	1.08	0.04	25	3.0	1.20	0.07
6	0.3	1.20	0.04	26	3.0	1.20	0.07
7	0.3	1.20	0.04	27	3.0	1.08	0.06
8	0.3	1.20	0.04	28	3.0	1.08	0.06
10	0.3	1.08	0.04	31	3.0	0.84	0.05
11	0.3	1.14	0.05	4- 1-30	3.0	0.88	0.05
13	0.3	1.20	0.05	2	3.0	0.90	0.04
14	0.3	1.20	0.05	3	3.0	0.96	0.04
15	0.4	1.20	0.04	4	3.0	0.90	0.05
17	0.4	1.20	0.05	7	3.0	0.84	0.05
18	0.4	1.20	0.04	8	3.0	1.08	0.06
19	0.4	1.20	0.04	9	3.5	0.96	0.05
20	0.4	1.20	0.04	10	3.5	1.08	0.06
21	0.4	1.20	0.04	11	3.5	0.84	0.05
24	1.0	1.08	0.05	12	3.5	1.26	0.07
25	2.0	1.08	0.05	14	3.5	1.20	0.06
26	3.0	1.08	0.06	15	4.5	0.54	0.02
27	3.0	1.08	0.05	16	4.5	0.78	0.04
28	3.0	1.08	0.06	17	4.5	1.26	0.05
3- 1-30	3.0	1.14	0.06	19	6.0	1.20	0.05
3	3.0	1.20	0.06	21	6.0	1.02	0.04
4	3.0	1.20	0.06	22	6.0	1.02	0.04
5	3.0	1.26	0.06	23	6.0	1.14	0.05
6	3.0	1.20	0.07	24	6.0	0.90	0.04
7	3.0	1.02	0.05	25	6.0	1.14	0.05
10	3.0	1.20	0.06	26	6.0	1.20	0.05
11	3.0	1.14	0.06	28	6.0	1.26	0.05
12	3.0	1.02	0.05	29	7.5	1.08	0.05
14	3.0	1.20	0.06	30	7.5	1.14	0.05

The bed longest in service, which was started in December, 1928, was washed for the first time August 28, 1929, and the second time January 23, 1930. We have merely guessed at the time the bed should be washed, for it was functioning all right just before washing. It might have been all right to run considerably longer, or it might have been better to wash more often. There was considerable turbidity in the wash water effluent which was composed largely of coagulated matter filtered from the water, but there is doubt whether this had any effect upon the efficiency of the bed. It was dechlorinating the water apparently just as efficiently before washing as after washing. This is shown by the tests recorded in table 1. The dechlorination apparently was just as effective the two or three days prior to washing as it was the two or three days following the wash. Had the flow been downward, more frequent washing would have been necessary to prevent the loss of head increasing too much. At least this has been the case with the glass tube filters that have been run with a downward flow.

Water has been passed through the larger carbon unit at a rate of 2 gallons per square foot per minute, except for a period of about two and one-half months from the latter part of December to the early part of March when a rate of about 1½ gallons was used. This was reduced to prevent flocculated matter passing the filter and not to give a longer contact time in the carbon adsorption bed. No attempt has been made to test the maximum rate that may be used in plant installations with the larger experimental unit, for it has been used to produce drinking water that is given away to thousands coming to the plant for the water and we did not want to take chances on giving away water with a slight chlorine taste. Tests on rates and depths of beds, however, have been made with the glass tube units and will be explained in another paragraph.

The only attention given the carbon unit by the filter operators during its seventeen months of operation has been to wash it twice. The rate is controlled by the filter, for all water that passes through the filter passes through the carbon bed. It is evident that the bed must eventually receive more attention in that it will be necessary occasionally to revivify the carbon in addition to the washing. Table 1 shows that it is gradually reducing in the percentage of the residual chlorine removed and that by the time it has been run twenty to twenty-five months it probably will have to be revivified, at least if the residual is continued as high as we have used in the experiment

most of the time up to date. The residual chlorine maintained in the water probably is higher than will ever be used in practice, and it is gratifying the know the bed has taken care of this high residual without difficulty.

The amount of residual chlorine in water that may be detected when no other taste-producing compounds are present is not known definitely. It is believed to be about 0.2 p.p.m., but perhaps some with very keen senses of taste may detect this amount and it may be better not to exceed 0.1. With a residual chlorine of 0.1 leaving the carbon units, it is likely that it will not exceed 0.05 part when it reaches the consumer, especially if it has to go through a clear water reservoir before being delivered. It is not believed there is any industrial use of water requiring the residual chlorine to be less than 0.05, but should there be it would not be very expensive for such industries to further dechlorinate the water.

SMALL SIZE CARBON UNITS FOR EXPERIMENTAL WORK

Those who have kept in touch with the writer's work for the past six or seven years are familiar with the glass tube filters about $1\frac{5}{8}$ inches in diameter used so extensively for experimental work.[4] This type of filter has been illustrated in previous articles. The glass tube carbon units are just like the filters except carbon is used for the bed instead of sand. Comparison of units of this size with larger units give results so close there can be little doubt as to the reliability of results obtained with these units. The dechlorination results of the Hydrodarco glass tube unit in table 2 compare very accurately with the dechlorination results of the larger unit given in table 1. Both carbon adsorption beds are of the same depth and have been operating at the same rate, except for very short periods when the rate was varied.

The glass tube units enable one to conduct experiments much more cheaply than with larger units and give results sufficiently accurate for all practical purposes. The small units may be changed from one location to another very easily, and can be operated under conditions not easy to obtain with large size units. Frequently it is the extreme condition that gives the more specific proof in experiments. The glass tube units have been used for comparing various brands of carbon, depths of beds, and rates of flow through the beds.

[4] Journal, June, 1927, page 710; The Experimental Filtration Plant of Chicago, Ill. Municipal News and Water Works, 76: 3, 89–95, March, 1929.

TABLE 2

Comparison of dechlorinating properties of 5 grades of carbon

Glass tube units about 1⅝ inches inside diameter

Beds 24 inches deep. Water passed through beds in a downward direction at the rate of 2 gallons per square foot per minute.

DATE	TEMPERATURE, °C.	RESIDUAL CHLORINE, P.P.M.					
		Applied water	Hydrodarco	Minchar	Woodchar	Bonechar	Nuchar
3-19-29	8.0	0.48	0.00	0.00	0.04	0.00	0.00
4- 4-29	9.0	0.90	0.00	0.02	0.06	0.00	0.00
9	9.0	0.30	0.00	0.00	0.00	0.00	0.00
13	8.0	0.72	0.00	0.02	0.08	0.00	0.00
15	8.0	0.84	0.00	0.01	0.04	0.00	0.00
16	10.0	0.96	0.00	0.02	0.05	0.00	0.00
19	9.0	0.54	0.00	0.01	0.04	0.00	0.00
20	10.0	1.44	0.00	0.04	0.07	0.01	0.00
22	10.0	1.20	0.00	0.02	0.06	0.01	0.00
23	11.0	1.20	0.00	0.02	0.05	0.01	0.00
24	11.0	0.96	0.00	0.02	0.04	0.01	0.00
25	11.0	1.08	0.00	0.02	0.06	0.01	0.00
26		0.96	0.00	0.02	0.06	0.01	0.00
27		0.72	0.00	0.01	0.04	0.01	0.00
Not operating 5-1-29 to 5-20-29							
5-22-29	12.0	0.36	0.00	0.00	0.01	0.00	
24		0.30	0.00	0.00	0.02	0.00	0.00
Not operating 5-28-29 to 6-15-29							
6-19-29	15.0	0.42	0.00	0.04	0.05	0.00	0.00
20	15.0	0.36	0.00	0.02	0.04	0.01	0.00
24	15.0	0.96	0.00	0.05	0.06	0.02	0.00
25	15.0	1.08	0.00	0.06	0.07	0.02	0.00
27	16.0	0.90	0.00	0.05	0.05	0.01	0.00
7- 2-29	17.0	0.96	0.00	0.04	0.06	0.02	0.00
6	18.0	0.96	0.00	0.02	0.05	0.04	0.00
10	15.0	1.44	0.00	0.07	0.12	0.06	0.00
16	18.0	0.60	0.00	0.02	0.02	0.01	0.00
17	18.0	1.08	0.00	0.04	0.04	0.02	0.00
19	19.0	1.08	0.00	0.04	0.05	0.02	0.00
23	19.0	0.72	0.00	0.02	0.02	0.02	0.00
24	19.0	0.72	0.00	0.02	0.02	0.02	0.00
25	19.0	0.60	0.00	0.02	0.02	0.04	0.00
26	20.0	1.08	0.00	0.02	0.01	0.04	0.00
29	20.0	1.02	0.00	0.04	0.04	0.05	0.00
31	20.0	0.72	0.00	0.00	0.02	0.02	0.00

TABLE 2—*Continued*

DATE	TEMPERATURE, °C.	RESIDUAL CHLORINE, P.P.M.					
		Applied water	Hydrodarco	Minchar	Woodchar	Bonechar	Nuchar
8- 2-29	21.0	1.08	0.00	0.04	0.04	0.04	0.00
Not operating 3 days							
6	21.0	0.84	0.00	0.04	0.05	0.05	0.00
13	22.0	1.02	0.00	0.02	0.04	0.04	0.00
20	20.0	1.08	0.00	0.02	0.02	0.04	0.00
21	20.0	0.96	0.00	0.02	0.02	0.02	0.00
22	20.0	0.90	0.00	0.01	0.02	0.02	0.00
28	21.0	1.44	0.00	0.00	0.02	0.01	0.00
29	21.0	1.20	0.00	0.00	0.02	0.02	0.00
30	21.0	0.96	0.00	0.01	0.02	0.02	0.00
9- 4-29	22.0	1.20	0.01	0.02	0.04	0.04	0.00
5	22.0	1.08	0.01	0.05	0.05	0.02	0.02
6	22.0	1.20	0.00	0.04	0.02	0.01	0.01
9	21.0	1.08	0.01	0.04	0.04	0.02	0.01
10	22.0	0.96	0.00	0.04	0.02	0.02	0.00
11	20.0	1.08	0.01	0.04	0.04	0.02	0.01
12	20.0	1.08	0.02	0.04	0.05	0.02	0.01
14	19.0	1.08	0.01	0.05	0.05	0.04	0.01
18	18.0	1.32	0.02	0.06	0.06	0.05	0.04
21	17.0	0.96	0.02	0.04	0.05	0.04	0.02
25	17.0	1.20	0.02	0.04	0.05	0.04	0.04
27	17.0	1.08	0.02	0.04	0.06	0.05	0.04
30	17.0	1.20	0.02	0.04	0.05	0.05	0.02
10- 2-29	17.0	1.20	0.02	0.05	0.06	0.05	0.02
4	16.0	1.20	0.02	0.05	0.06	0.05	0.04
7	15.0	1.20	0.02	0.05	0.05	0.05	0.02
8	15.0	1.44	0.01	0.05	0.02	0.04	0.02
16	15.0	1.20	0.02	0.06	0.05	0.06	0.04
11- 4-29	10.0	1.44	0.02	0.07	0.05	0.05	0.07
5	10.0	1.20	0.02	0.06	0.05	0.04	0.06
7	9.0	1.20	0.02	0.06	0.06	0.05	0.06
9	9.0	1.32	0.02	0.06	0.06	0.04	0.06
19	8.0	1.44	0.04	0.06	0.06	0.04	0.06
20	8.0	1.44	0.04	0.06	0.06	0.05	0.07
22	6.0	1.68	0.04	0.07	0.06	0.06	0.07
26	5.0	1.32	0.04	0.06	0.05	0.05	0.06
29	3.0	1.20	0.04	0.06	0.06	0.06	0.06

TABLE 2—*Concluded*

DATE	TEMPERATURE, °C.	RESIDUAL CHLORINE, P.P.M.					
		Applied water	Hydrodarco	Minchar	Woodchar	Bonechar	Nuchar
12- 3-29	1.0	1.32	0.04	0.07	0.08	0.06	0.05
5	1.0	1.20	0.04	0.07	0.08	0.07	0.06
10	1.0	1.32	0.04	0.07	0.08	0.07	0.05
12-13-29	0.6	1.44	0.05	0.08	0.08	0.07	0.06
18	0.6	0.96	0.04	0.07	0.08	0.10	0.05
27	0.4	1.44	0.06	0.12	0.17	0.11	0.05
30	0.4	1.20	0.05	0.08	0.12	0.07	0.06
1- 3-30	0.4	1.08	0.05	0.12	0.18	0.12	0.07
8	0.4	1.32	0.07	0.18	0.26	0.19	0.11
15	0.4	0.96	0.06	0.12	0.20	0.14	0.08
22	0.4	1.44	0.08	0.24	0.48	0.30	0.13
23	0.4	1.44	0.08	0.30	0.54	0.36	0.13
29	0.4	1.20	0.06	0.22	0.42	0.22	0.10
31	0.4	1.20	0.06	0.19	0.42	0.20	0.08
2- 5-30	0.4	1.20	0.01	0.18	0.30	0.17	0.08
11	0.3	1.14	0.01	0.19	0.34	0.20	0.08
24	1.0	1.08	0.06	0.20	0.24	0.19	0.07
28	3.0	1.08	0.06	0.28	0.32	0.15	0.10
3- 1-30	3.0	1.14	0.06	0.36	0.32	0.20	0.12
11	3.0	1.08	0.05	0.36	0.38	0.22	0.14
19	3.0	1.20	0.07	0.33	0.42	0.24	0.14
27	3.0	1.08	0.06	0.38	0.42	0.26	0.18
4- 4-30	3.0	0.90	0.06	0.24	0.30	0.18	0.12
10	3.5	0.90	0.05	0.24	0.34	0.20	0.10
17	4.5	1.32	0.06	0.30	0.38	0.36	0.14
24	6.0	1.26	0.08	0.32	0.48	0.42	0.12

DEPTHS OF BEDS AND RATES OF FLOW

These two subjects are so dependent upon each other that it is almost impossible to discuss one without the other. The most suitable depth of bed has not been determined. A bed 6 feet in depth should give the same time of contact between the carbon and the water as a bed 2 feet in depth and 3 times the size of the deeper bed. Some experimenters claim that a deeper bed with a high rate of flow is better than a shallower bed with slower rates. Experiments indi-

TABLE 3

Dechlorination with activated carbon

Glass tube unit no. C-4. Forty-eight inches of Hydrodarco

Carbon unit no. C-4 was filled to a depth of 48 inches with 4–12 mesh Hydrodarco from carbon unit no. 8. This is material that has been in service since December 28, 1928.

DATE	RATE OF FLOW (GALLONS PER SQUARE FOOT PER MINUTE)	RESIDUAL CHLORINE, P.P.M.		DATE	RATE OF FLOW (GALLONS PER SQUARE FOOT PER MINUTE)	RESIDUAL CHLORINE, P.P.M.	
		Applied water	Effluent carbon unit			Applied water	Effluent carbon unit
2– 7–30	2.0	1.20	0.00	3– 5–30	4.0	1.26	0.02
7	2.0	1.20	0.00	6	4.0	1.20	0.02
8	2.0	1.20	0.00	7	4.0	1.02	0.02
8	2.0	1.20	0.00	10	6.0	1.20	0.04
10	2.0	1.08	0.00	10	6.0	1.14	0.04
10	2.0	1.08	0.00	11	6.0	1.08	0.02
11	2.0	1.14	0.00	12	6.0	1.02	0.02
11	2.0	1.20	0.00	13	6.0	1.14	0.02
13	2.0	1.20	0.00	14	6.0	1.20	0.03
13	2.0	1.20	0.00	17	6.0	1.26	0.04
14	2.0	1.20	0.00	18	6.0	1.08	0.04
14	2.0	1.20	0.00	19	6.0	1.20	0.04
15	2.0	1.20	0.00	20	6.0	1.20	0.05
17	4.0	1.20	0.01	21	6.0	1.26	0.05
17	4.0	1.14	0.01	24	6.0	1.02	0.04
18	4.0	1.20	0.01	25	6.0	1.20	0.05
19	4.0	1.20	0.01	26	6.0	1.20	0.05
19	4.0	1.20	0.01	27	6.0	1.08	0.04
20	4.0	1.20	0.00	28	6.0	1.08	0.04
20	4.0	1.20	0.01	31	6.0	0.84	0.02
21	4.0	1.20	0.01	4– 1–30	6.0	0.89	0.02
24	4.0	1.08	0.01	2	6.0	0.90	0.01
25	4.0	1.08	0.01	3	6.0	0.96	0.02
26	4.0	1.08	0.02	4	6.0	0.90	0.02
27	4.0	1.08	0.02	7	6.0	0.84	0.03
27	4.0	1.08	0.02	9	6.0	0.96	0.02
28	4.0	1.08	0.02	10	6.0	0.90	0.04
3– 1–30	4.0	1.14	0.02	11	6.0	0.84	0.04
3	4.0	1.20	0.02	12	6.0	1.26	0.04
4	4.0	1.20	0.02	14	6.0	1.20	0.05

TABLE 3—*Concluded*

DATE	RATE OF FLOW (GALLONS PER SQUARE FOOT PER MINUTE)	RESIDUAL CHLORINE, P.P.M. Applied water	RESIDUAL CHLORINE, P.P.M. Effluent carbon unit	DATE	RATE OF FLOW (GALLONS PER SQUARE FOOT PER MINUTE)	RESIDUAL CHLORINE, P.P.M. Applied water	RESIDUAL CHLORINE, P.P.M. Effluent carbon unit
4-15-30	6.0	0.54	0.01				
16	6.0	0.78	0.01				
17	6.0	1.26	0.04				
19	6.0	1.20	0.04				
21	6.0	1.02	0.02				
22	6.0	1.02	0.04				
23	6.0	1.14	0.04				
24	6.0	0.90	0.04				
25	6.0	1.14	0.05				
26	6.0	1.20	0.04				
28	6.0	1.26	0.05				
29	6.0	1.08	0.04				
30	6.0	1.14	0.05				

cate there is some justification for this claim. It will be noted from table 3 that material removed from carbon unit No. 8, which is the larger unit, and placed in a glass tube unit to a depth of 4 feet gives more effective dechlorination at a rate of 4 gallons per square foot per minute than a bed 2 feet in depth at a rate of 2 gallons. It also is noted that a bed 6 feet in depth gives as good results at 12 gallons per square foot per minute as a bed 2 feet in depth at 2 gallons. These experiments were made with 4–12 mesh Hydrodarco.

High rates with an upward flow suspend the material unless it is held down in some manner. With the 4–12 mesh Hydrodarco the highest upward flow that may be maintained without suspending the material is about 4 gallons per square foot per minute. This would indicate that a working rate of approximately 3 gallons per square foot per minute is about as high as we should go with this material when the flow is upward if we do not wish any of the material to be suspended. There may be no objection to having the material partially suspended if the wear due to abrasion is not too great. The writer ran a glass tube Hydrodarco unit over one month with an upward flow of about 13 gallons per square foot per minute without a screen to prevent loss of the carbon. A small amount of the finer material washed away, but most of it remained in the tube in par-

tial suspension, somewhat like sand is suspended when a filter is washed. The unit gave very good dechlorination during the run.

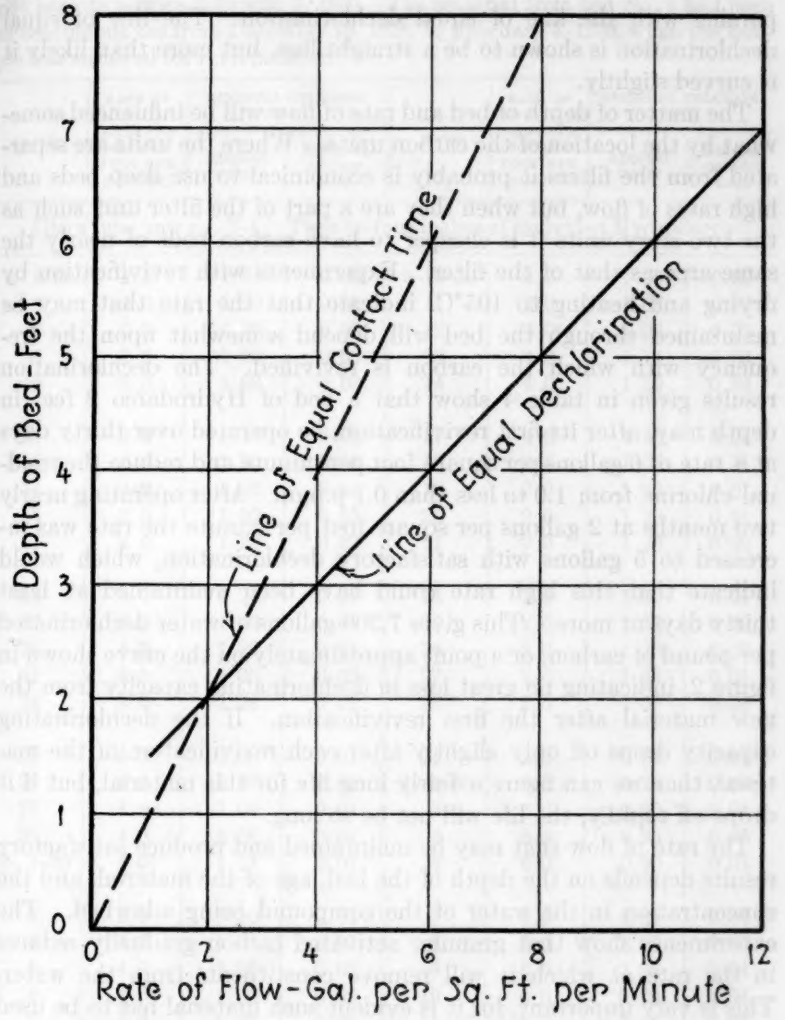

FIG. 1. RELATION BETWEEN DEPTH OF BED AND RATE OF FLOW FOR EQUAL DECHLORINATION

With a downward flow higher rates may be used, though the friction loss through the bed will be greater. A downward flow also would

bring about more complications in controlling the rate. Figure 1 shows the approximate relation between the depth of bed and rate of flow. It will be noted that the line of equal contact time is not parallel with the line of equal dechlorination. The line of equal dechlorination is shown to be a straight line, but more than likely it is curved slightly.

The matter of depth of bed and rate of flow will be influenced somewhat by the location of the carbon units. Where the units are separated from the filters it probably is economical to use deep beds and high rates of flow, but when they are a part of the filter unit such as the two-story units it is cheaper to have carbon beds of nearly the same area as that of the filter. Experiments with revivification by drying and heating to 105°C. indicate that the rate that may be maintained through the bed will depend somewhat upon the frequency with which the carbon is revivified. The dechlorination results given in table 4 show that a bed of Hydrodarco 2 feet in depth may, after its first revivification, be operated over thirty days at a rate of 6 gallons per square foot per minute and reduce the residual chlorine from 1.0 to less than 0.1 p.p.m. After operating nearly two months at 2 gallons per square foot per minute the rate was increased to 6 gallons with satisfactory dechlorination, which would indicate that this high rate could have been maintained at least thirty days or more. This gives 7,200 gallons of water dechlorinated per pound of carbon, or a point approximately on the curve shown in figure 2, indicating no great loss in dechlorinating capacity from the new material after the first revivification. If the dechlorinating capacity drops off only slightly after each revivification of the material, then we can figure a fairly long life for this material, but if it drops off rapidly, the life will not be so long.

The rate of flow that may be maintained and produce satisfactory results depends on the depth of the bed, age of the material, and the concentration in the water of the compound being adsorbed. The experiments show that granular activated carbon gradually reduces in the rate at which it will remove constituents from the water. This is very important, for it is evident such material has to be used for a fairly long time to be economical. The curves in figure 2 may not be accurate, except where points are shown, but they give some idea of what to expect with granular Hydrodarco. The writer hopes to give curves drawn from a large number of points at a later date, and they may be slightly different from the ones shown in fig-

TABLE 4

Revivification of Hydrodarco by heating

Material taken from Carbon Unit No. 8, heated to 105°C. for 18 hours, then put back in service February 5, 1930. The material from bed No. 8 had been in continuous use from December 26, 1928, to February 4, 1930, when the sample was removed for revivification.

DATE	RATE OF FLOW (GALLONS PER SQUARE FOOT PER MINUTE)	RESIDUAL CHLORINE, P.P.M.		DATE	RATE OF FLOW (GALLONS PER SQUARE FOOT PER MINUTE)	RESIDUAL CHLORINE, P.P.M.	
		Applied water	Effluent carbon unit			Applied water	Effluent carbon unit
Glass tube unit no. T-1. Twenty-four inches of revivified Hydrodarco							
2–5–30	2.0	1.14	0.00	3–10–30	4.0	1.20	0.02
6	2.0	1.20	0.01	11	4.0	1.08	0.02
7	2.0	1.20	0.00	12	4.0	1.02	0.02
8	2.0	1.20	0.00	13	4.0	1.14	0.03
10	2.0	1.08	0.00	14	4.0	1.20	0.04
11	2.0	1.14	0.00	17	4.0	1.26	0.04
13	2.0	1.20	0.01	18	2.0	1.08	0.01
14	2.0	1.20	0.01	19	2.0	1.20	0.01
15	2.0	1.20	0.01	20	2.0	1.20	0.01
17	4.0	1.20	0.02	21	2.0	1.26	0.02
18	4.0	1.20	0.01	24	2.0	1.02	0.01
19	4.0	1.20	0.01	25	2.0	1.20	0.02
20	4.0	1.20	0.01	26	2.0	1.20	0.02
21	4.0	1.20	0.02	27	2.0	1.08	0.01
24	4.0	1.08	0.01	28	2.0	1.08	0.02
25	4.0	1.08	0.01	31	2.0	0.84	0.01
26	4.0	1.08	0.01	4–1–30	6.0	0.89	0.04
27	4.0	1.08	0.01	2	6.0	0.90	0.04
28	4.0	1.08	0.01	3	6.0	0.96	0.05
3–1–30	4.0	1.14	0.01	4	6.0	0.90	0.04
3	4.0	1.20	0.01	7	6.0	0.84	0.04
4	4.0	1.20	0.02	8	6.0	1.08	0.05
5	4.0	1.26	0.02	9	6.0	0.96	0.04
6	4.0	1.20	0.02	10	6.0	0.90	0.04
7	4.0	1.02	0.02	11	6.0	0.84	0.05

TABLE 4—*Concluded*

DATE	RATE OF FLOW (GALLONS PER SQUARE FOOT PER MINUTE)	RESIDUAL CHLORINE, P.P.M. Applied water	RESIDUAL CHLORINE, P.P.M. Effluent carbon unit	DATE	RATE OF FLOW (GALLONS PER SQUARE FOOT PER MINUTE)	RESIDUAL CHLORINE, P.P.M. Applied water	RESIDUAL CHLORINE, P.P.M. Effluent carbon unit
Glass tube unit no. W-1. Twenty-four inches of revivified Hydrodarco							
4-12-30	6.0	1.26	0.07				
14	6.0	1.20	0.06				
15	6.0	0.51	0.02				
16	6.0	0.78	0.04				
17	6.0	1.26	0.06				
19	6.0	1.20	0.05				
21	6.0	1.02	0.05				
22	6.0	1.02	0.04				
23	6.0	1.08	0.05				
24	6.0	0.90	0.05				
25	6.0	1.14	0.06				
26	6.0	1.20	0.07				
28	6.0	1.26	0.06				
29	6.0	1.08	0.06				
30	6.0	1.14	0.06				

ure 2. However, those shown are not greatly in error for the particular material used. The curves in figure 2 are based on the gallons of water dechlorinated per pound of carbon on first run carbon. Assume the water has a residual chlorine of 1.0 p.p.m. going to the carbon and that it passes through a bed of the 4 to 12 mesh Hydrodarco 24 inches in depth. One pound of the material will dechlorinate about 30,000 gallons of water to the extent that not more than 0.1 p.p.m. of residual chlorine will be left in the water when the rate of flow is two gallons per square foot per minute. With a bed 48 inches in depth, approximately 50,000 gallons of water per pound of Hydrodarco may be dechlorinated to the same extent when the rate is only two gallons per square foot per minute. This is based upon its first use and without revivification. If it were not possible to revivify the material, certainly deep beds or very slow rates would be the most economical procedure.

In using the curves in figure 2 to compute the probable cost of carbon it should be understood that they are based on the first use of

the material; that is, without revivification. We have no information as to the number of times the material may be revivified. The total water that may be dechlorinated with a given weight of carbon before it is no longer able to give the desired dechlorination or taste elimination may be 5 to 10 times that indicated by the first run. One pound of Hydrodarco may dechlorinate from 200,000 to 500,000 gallons of water. This is something that can be told only by several years use of the material.

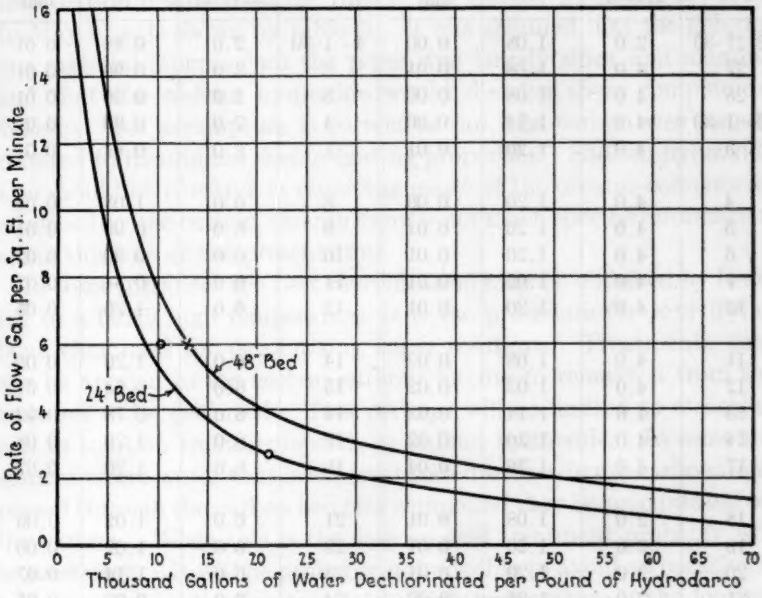

FIG. 2. GALLONS OF WATER DECHLORINATED FROM 1.0 P.P.M. PER POUND OF HYDRODARCO AT VARIOUS RATES OF FLOW

REVIVIFICATION

The time to revivify the carbon will depend upon its use and its effectiveness in removing the objectionable constituents from the water. The method of revivification will depend somewhat on what the material has adsorbed. In some instances the reduction in activity of the carbon may be due to stopping up of the pores with gelatinous precipitates. The writer has made no extensive study of revivification, for our material longest in use has not as yet reached the point where it needs revivification with the slow rate of flow

TABLE 5

Revivification of Hydrodarco by treating with sodium hydroxide

Material taken from Carbon Adsorption Bed No. 8, and placed in a 1.0 per cent solution of hot sodium hydroxide for about 2 hours. It was then washed nearly free from the alkali and a sufficient amount placed in Glass Tube Adsorption Bed U-1 to fill it 24 inches in depth.

DATE	RATE OF FLOW (GALLONS PER SQUARE FOOT PER MINUTE)	RESIDUAL CHLORINE, P.P.M.		DATE	RATE OF FLOW (GALLONS PER SQUARE FOOT PER MINUTE)	RESIDUAL CHLORINE, P.P.M.	
		Applied water	Effluent carbon unit			Applied water	Effluent carbon unit
2-27-30	2.0	1.08	0.00	4- 1-30	2.0	0.88	0.01
27	4.0	1.08	0.01	2	2.0	0.90	0.01
28	4.0	1.08	0.00	3	2.0	0.96	0.01
3- 1-30	4.0	1.14	0.00	4	2.0	0.90	0.01
3	4.0	1.20	0.01	7	2.0	0.84	0.01
4	4.0	1.20	0.00	8	6.0	1.08	0.05
5	4.0	1.26	0.01	9	6.0	0.96	0.04
6	4.0	1.20	0.01	10	6.0	0.90	0.02
7	4.0	1.02	0.01	11	6.0	0.84	0.02
10	4.0	1.20	0.01	12	6.0	1.26	0.05
11	4.0	1.08	0.02	14	6.0	1.20	0.05
12	4.0	1.02	0.02	15	6.0	0.54	0.01
13	4.0	1.14	0.02	16	6.0	0.78	0.02
14	4.0	1.20	0.02	17	6.0	1.26	0.08
17	4.0	1.26	0.04	19	6.0	1.20	0.07
18	2.0	1.08	0.01	21	6.0	1.02	0.06
19	2.0	1.20	0.01	22	6.0	1.02	0.06
20	2.0	1.20	0.01	23	6.0	1.14	0.07
21	2.0	1.26	0.02	24	6.0	0.90	0.05
24	2.0	1.02	0.01	25	6.0	1.14	0.06
25	2.0	1.20	0.05	26	6.0	1.20	0.06
26	2.0	1.20	0.02	28	6.0	1.26	0.06
27	2.0	1.08	0.01	29	6.0	1.08	0.06
28	2.0	1.08	0.01	30	6.0	1.14	0.07
31	2.0	0.84	0.01				

through the beds being used. When the chief use of the carbon is for dechlorination it is likely that its decrease in efficiency is due more to gelatinous materials stopping up the pores than to adsorbed compounds. In this case the best method would be something that removes the gelatinous material.

The material used in the glass tube Carbon Unit No. T-1 was taken from Carbon Unit No. 8, and dried about eighteen hours at 105°C. before placing in the tube. This unit with the revivified carbon was put into service February 5, 1930. The results obtained by this material as shown by table 4 are almost the same as for the new material. Another portion from Carbon Unit No. 8 was treated with a hot solution of 1 percent sodium hydroxide, washed, and put into another glass tube unit. This also has given very good dechlorination results from the time it was started February 27, 1930, to May 1, as is shown by table 5. It was assumed that the gelatinous material stopping up the pores was largely silica and alumina and that the sodium hydroxide would dissolve these compounds. Whether this assumption is correct or not, the carbon was largely restored to its original dechlorinating properties. Sodium hydroxide also should be effective in removing many of the organic compounds adsorbed by the carbon, though there is not much specific information along this line at the present time.

In some instances the best revivification may be obtained by heating to a fairly high temperature as is the procedure for revivifying bone char used for decolorizing sugar solutions. Treatments that can be applied to the carbon without having to remove it from the beds are to be preferred. This perhaps will be limited to steaming and to solution treatments such as sodium hydroxide. In some instances where water that is supersaturated with calcium carbonate is passed through the carbon bed this compound may be precipitated on the carbon. When this is the case an acid treatment probably will be necessary. It will be probably not possible to avoid an occasional revivification by heating to a fairly high temperature if the longest life of the material is to be obtained.

BRANDS OF CARBON SUITABLE FOR DECHLORINATION

Almost any carbonaceous material is capable of being made active for adsorption and for dechlorination. The experiments to date have been largely on testing the dechlorinating properties of the various materials, for this very likely will constitute its chief use in water purification. From the materials given in table 2 it is evident that no effort has been made to compare all brands of carbon now on the market. The comparison was started with materials that happened to be on hand at the time. It is intended to extend the work later to include more materials, but the materials used give some

indication of the suitability of carbons differing widely in character for dechlorinating purposes.

There is no direct relation between the carbon content of materials and the hardness of the granules, but, in general, the very hard materials are low in carbon content and those high in carbon content are usually not very hard. Bone char and Minchar are very hard materials, but they contain only about 10 percent of carbon. Fruit pits and cocoanut shells produce fairly hard materials with high carbon content. Preliminary experiments on cocoanut shell char indicates that it is a very active material, whereas the particular sample of peach pits tried was not very active though high in carbon content and fairly hard. Hydrodarco, which is produced from lignite, is neither very soft nor very hard. Its hardness, however, is sufficient for water works use.

TABLE 6
Weight of commercial activated carbons

	Weight of material per cubic foot, pounds	Approximate percentage of carbon	Pounds of actual carbon per cubic foot
Hydrodarco	17.2	70	12.0
Cocoanut char	24.4	96	23.4
Nuchar	9.1	93	8.5
Bonechar	35.1	10	3.5
Minchar	41.6	10	4.2
Wood charcoal*	9.8	97	9.5
Peach pits	21.2	98	20.8

* Not activated.

Fruit pits and cocoanut shells are by-products of other industries and carbons made from them probably would not maintain their present price if there was a very great demand. There is an abundance of lignite and we should not expect the prices of carbon derived from this source to increase in price with an increase in demand. In fact a greater use might lessen the price. Table 6 shows the weight, approximate percentage of carbon, and the computed pounds of actual carbon per cubic foot of the commercial material for several brands of carbons. Just what percentage of the actual carbon in a material is available for dechlorinating and adsorbing purposes is not known. If only one-half of it were available in the materials high in carbon content, it would not be a very expensive dechlorinating material.

SUPERCHLORINATION FOLLOWED BY DECHLORINATION WITH CARBON IS PROBABLY THE MOST DESIRABLE TREATMENT

Considerable thought has been given to the most desirable treatment for municipal supplies to remove taste-producing compounds from water. Active carbon will adsorb most if not all of the taste-producing compounds, and it might seem useless to use the chlorine. Superchlorination, however, will oxidise or change to inoffensive compounds many of the taste-producing compounds, but the excess chlorine must be removed from the water or it might be almost as objectionable as the compound it had changed or broken down. The reaction of chlorine with carbon is to oxidise the carbon, forming hydrochloric acid and carbon dioxide. In other words, dechlorination is a direct chemical action, whereas the removal of practically all other compounds is by adsorption. The ease with which residual chlorine tests may be made enables the operator to give close supervision. The chemist, at the present time, cannot determine accurately the compounds in water producing what is known as algae tastes or even many of the other tastes. If we know that a certain excess of chlorine will always change the offensive compounds to inoffensive compounds, then the guide for determining the proper treatment becomes the residual chlorine test, which is easy to make, instead of some complicated test too difficult for the average water works laboratory.

If a water purification plant has good chemical supervision and if treatments, other than activated carbon for removing the taste-producing compounds are found to be efficient and economical, then there is no objection to using the treatments, provided they really eliminate the taste beyond detection. From such information as the writer has been able to gather from places using taste-elimination treatments, there is not complete elimination of all objectionable tastes all the time. Either the elimination is incomplete or it is impossible to apply the chemicals with a regularity essential for complete elimination all the time, but there is a great improvement over no treatment. With the experimental unit operated by the writer there has not been a single time since it started operation the latter part of 1928 in which there was even the slightest taste. No special attention is given to the treatment. The filter attendants have instructions to keep the chlorine machine running uniformly at the rate given them by the chemist, and everything else in connection

with the taste elimination treatment takes care of itself. If we were operating on a very close margin of chlorine necessary to produce the desired results, then it would be necessary to make frequent residual chlorine tests, but even this is unnecessary with the very high residual used. Residual chlorine tests have been made once each day, unless some special experiment is being run.

Any operator capable of operating a small filtration plant can use this treatment and eliminate all the tastes just as easily as they can be eliminated in the larger plants where there is more skilled supervision. Whether it is the superchlorination that does the major part of the work or the carbon is not known. The chlorine may keep the bed sufficiently active for removing such taste-producing compounds as may escape being changed by the chlorine or else practically all compounds are changed. It would be nice to know that the carbon had nothing to do but dechlorinate, but we know there are a few waters polluted with compounds that are not rendered inoffensive by chlorine. In these waters the treatment might not be such that freedom from taste may be assured by the residual chlorine test. Such plants should be under the control of a competent chemist so that the carbon may be revivified before it reaches the point where objectionable tastes will pass the carbon unit. All filtration plants, of course, should be operated under the direction of a competent chemist, but it is not necessary to have a chemist merely to supervise the taste elimination process in most plants when the water is superchlorinated and then dechlorinated with active carbon.

SUMMARY

Seventeen months operation of an experimental carbon unit are described.

Very little attention has been given to the unit. It has been washed twice, with washing in the same general manner as for rapid sand filters.

Glass tube units about $1\frac{5}{8}$ inches in diameter have been used for experiments on various grades of carbon, depths of beds, and rates of flow. Results of the tests on the small size units compare very favorably with larger size units.

Experiments indicate that fairly deep beds are to be preferred; that is, a bed 48 inches in depth will reduce the residual chlorine to a lower figure at a rate of 4 gallons per square foot per minute than a bed 24 inches in depth at 2 gallons per square foot per minute.

Either an upward or downward flow through the carbon units may be used. The maximum upward flow to avoid suspension of the material is about 4 gallons per square foot per minute for 4–12 mesh Hydrodarco. Higher rates may be used with a downward flow, but there will be considerable friction loss through the bed.

Downward flows will require more frequent washing of the unit than upward flows, due to the beds becoming clogged.

Only a few experiments have been made on revivifying the carbon. When the loss of activity is due largely to gelatinous compounds stopping up the pores of the carbon, drying at 105°C., or treating with a hot solution of sodium hydroxide revivified the material for dechlorination. The most suitable revivification will depend somewhat on what the material has adsorbed.

Materials differing widely in carbon content are suitable for dechlorination.

Superchlorination followed by dechlorination with active carbon removes practically all taste-producing compounds that are likely to be present in water. Algae tastes are completely removed by this treatment.

One pound of Hydrodarco will reduce the residual chlorine in about 30,000 gallons of water from 1.0 to less than 0.1 p.p.m. without revivification when the water is passed through a bed of the carbon 24 inches in depth at a rate of 2 gallons per square foot per minute. By revivifying the material it is believed that 200,000 to 500,000 gallons of water may be dechlorinated per pound of Hydrodarco.

The experiments in this paper were directed by the writer, and all tests given in the tables were made by Oscar Gullans, Chemist at the Experimental Filtration Plant. The writer wishes to express his appreciation of the assistance and cooperation, in making these experiments possible given by Richard W. Wolfe, Commissioner of Public Works; Loran D. Gayton, City Engineer; and Henry A. Allen, Mechanical Engineer in Charge Division of Operation.

DISCUSSION

Paul Hansen:[5] These papers on the use of activated carbon are valuable contributions to the literature on water purification. The positiveness with which this material removes tastes and odors from water insures for it a permanent place among water purification devices.

Its application, however, must be made with a degree of circumspection, inasmuch as the inclusion of activated carbon treatment in connection with filtration will involve more radical changes in filter plant design and involve more installation expense than any change in water purification practice proposed for many years. Engineers designing plants embodying activated carbon will be particularly anxious to know what the use of this material will cost in the long run, what kind of material is best and most economically adaptable, what operating troubles are likely to be encountered and what represents best design.

The authors have thrown much light on these questions, but there are still some uncertainties that require further experiments and experience. Some questions and commentaries which come to mind in reading these papers are as follows:

How much purification or clarification is necessary to insure a reasonably long and economical use of activated carbon? This is a particularly important question with reference to the smaller plants which produce none too perfect clarification of the water and often the filtered water contains appreciable quantities of aluminum hydrate.

Is not super-chlorination essential to prevention of clogging growths that may very quickly prevent functioning of the activated carbon?

Will disintegration of the material cause substantial losses and will it cause considerable deposits of finely divided carbon in the clear water reservoirs?

Revivification of activated carbon seems costly and more or less troublesome. Although not required frequently, it must be done and it must not involve too much complexity, especially in a small in-

[5] Consulting Engineer, of Pearse, Greeley and Hansen, Chicago, Ill.

stallation. Revivification with steam is proposed by Imhoff and Sierp and apparently has also been used experimentally in the United States. If steam is effective, it seems to constitute the most readily applicable means of revivification.

Inasmuch as troublesome tastes and odors do not always occur continuously in a water supply, some consideration might be given to intermittent use of activated carbon by way of economy.

Mr. Behrman has presented a number of suggested designs for utilization of activated carbon in conjunction with filtration. The simplest for existing plants is the use of the pressure filter type of carbon unit. In this connection the question arises as to the probable danger of finely divided carbon entering the distribution system.

A reading of the papers leaves somewhat obscure the necessity for and the desirable frequency of washing activated carbon units. Some may ask why wash the material at all if the water is properly clarified and sterilized?

There is a marked discrepancy in the upward rates of motion of water passing through active carbon in the two papers. Mr. Baylis suggests a maximum of 4 gallons per square foot per minute, while Mr. Behrman suggests 12 to 15 gallons per square foot per minute.

Undoubtedly, progress in the application of activated carbon will be observed with great interest by all engaged in water purification. If its effectiveness, ease of applicability and reasonable economy can be fully demonstrated, it will undoubtedly become widely used. It must not be assumed, however, that the availability of activated carbon will permit relaxation in securing the elimination of taste producing industrial wastes at their source.

R. A. Hoot:[6] I have read the excellent paper by Messrs. Behrman and Crane with considerable interest for during the past few months a large proportion of my work has been devoted to a study of eliminating odors from water; a study which at one time appeared to be developing into one of determining the feasibility of utilizing activated carbon filtration on the water under consideration. In contributing to this discussion I shall merely present some of the information we have gathered in experimenting with Hydrodarco to eliminate odors from an inland lake water, odors which undoubtedly are caused by dead vegetation.

[6] Civil Engineer, Department of Water Supply, Pontiac, Mich.

In this study two separate tests were made with Hydrodarco. The first one was started December 18, 1929 and ended March 18, 1930; the second was started April 1 and is still in progress. In these tests small filters, each 2.7 square feet in area, were utilized. These were placed in the pipe gallery of a rapid sand filter plant and connected to the effluent of one of the plant sand filters. The water passing into the Hydrodarco filters was lake water which had merely been strained, without any chemical clarification, through 30 inches of filter sand. The applied water, that is, that passing to the Hydrodarco, had a slight trace of turbidity, a color of 5 p.p.m., and an oxygen consumed value of 7.5 p.p.m. As far as these constituents are concerned the water was practically of constant quality.

During the first test from December 18 to March 18 the water applied to the Hydrodarco had a noticeable straw-like hot odor and a slight moldy tasted odor. The water passing the experimental filter was absolutely devoid of these deficiencies. In addition the Hydrodarco had decreased the oxygen consumed value from 7.5 to 2.5 p.p.m., and eliminated the 5 parts of color. This filter was operated continuously, with upward flow, at 87 m.g.a.d. rate. The Hydrodarco was 16 inches thick, or in terms of a 24 inch layer of carbon, the rate was approximately 125 m.g.a.d. The filter was as effective March 18 as it was December 18.

In the second test, which was started April 1 and is still in progress, two separate filters are used. One of these has 12 inches of carbon and the other 24 inches. The rates of both are approximately 100 m.g.a.d. The water applied to these filters has varied somewhat in the intensity of its odors. The odors in this water increase in intensity with the increase in the temperature of the water, but as a rule they have been sufficiently intense so that any person would readily notice the hot straw-like odor and, on second thought, would detect the moldy after odor. The water first passing the carbon was devoid of odors, but within two weeks the faint straw-like hot odor could be detected and within four weeks the tasted odor was noticeable. These gradually increased in intensity until after seven weeks operation both were readily distinguishable. The results of the oxygen consumed test also indicated the ineffectiveness of the Hydrodarco. April 1 this test showed 2.5 p.p.m. in the effluent of both filters. Within three weeks it had increased to 3.3 p.p.m. and at the end of seven weeks it was 6.5 p.p.m. It is interesting to note in this connection that the results of the oxygen consumed test on the water

passing the 12 inch layer of carbon have been practically identical with those made on the water passing the 24-inch layer.

By the end of the seven weeks operation it appeared that the Hydrodarco would soon be ineffective. Shortly thereafter it was decided to chlorinate the water applied to the sand filter and for the past two weeks this has been done for one-half hour each morning at the rate of 10 p.p.m.

ROBERT SPURR WESTON:[7] In the preparation of the paper by Messrs. Norcom and Dodd the authors, with whom the speaker has had the pleasure of working during many months of experiments, have covered ably the main points brought out by the investigation and have entered into details as far as the results and the limits of a paper of this kind warrant. Therefore, it may be permitted the discussor of the paper to mention some of the matters which are more or less speculative.

The experiments with carbon at Chester followed repeated tests in the laboratory with all known combinations of water—purifying chemicals and months of experiments on a small scale using various chemical treatments with and without aeration, using for the latter process both ordinary spray nozzles and a trickling filter of coke 10 feet deep, operating at various rates.

These experiments showed that a combination of chemical treatment and aeration would be successful for odor removal during most of the time, but only partly successful for the remainder of the time.

The incompleteness of excessive treatment using a combination of chemicals and commonly used methods and the successes on a small scale at Chicago and Cleveland and a large scale abroad by the use of activated carbon, led to the described experiments; which have demonstrated an effective method for removing odors from a water most difficult to treat.

Regarding the nature of these odors or odor producing substances, one can only speculate. It is true that they are caused by minute quantities of substances which have been shown to be largely volatile and oxidizable. Probably they are semistable, that is, they have undergone partial decomposition and are in a stage where they are noticeably disagreeable. They oxidize slowly and with difficulty to odorless compounds and the time required for de-odorization by oxidation is beyond that provided in most plants. It is because

[7] Consulting Engineer, of Weston and Sampson, Boston, Mass.

of this long time-factor and because activated carbon has the power of storing these substances until they can be consumed that the described process has a wide field of usefulness.

At Chester the worst odors occur in the spring or late winter. Probably deposits of the organic matter contained in sewage sludge and in industrial wastes accumulate during the period of low stream flow and low temperature and when re-aeration is hindered by ice. Apparently the stirring up of these products by the first high flows of the year intensifies the bad odor and taste.

While the odor may be due in part to chlorine, it is more closely related to the odor of decaying organic matter. It is due in part to petroleum compounds, but these alone are not serious from a purification standpoint. As the authors have stated the odor is in some way related to the nitrogen content and may be due to compounds of sulfur and organic matter. Whatever it is, it is removed by activated carbon.

Regarding the rate of filtration, it was evident from the experiments that a downward rate of 2.0 gallons per square foot per minute through 30 inches of Darco was satisfactory. This is equivalent to 0.8 g.p.m. per cubic foot. Consequently a bed 5 feet deep might be operated at a rate of 4.0 gallons per square foot.

The speaker agrees with the authors that upward-flow units are less effective for any given depth and rate because, especially the shallow ones, are not closely packed when in operation and consequently intimate contact between water and carbon does not take place. With a thicker bed, the differences probably would be minimized.

Upward-flow carbon units possess the advantage of low losses of head. The loss of material may be largely prevented by the use of outlet strainers such as, are used in zeolite water softeners operating on the same principles.

A modification of the arrangements of Baylis might be made by placing the carbon in a basin alongside the filtered water basin, thus providing a means for regenerating such an upward flow unit by steaming.

Experiments in the laboratory of Weston and Sampson demonstrated that super-heated steam is much more effective for regenerating carbon than steam at 212°F. Sufficiently high temperatures cannot be obtained by the use of heated air because the carbon absorbs oxygen so rapidly that it takes fire.

It might be stated for general information, that the owners of the plant at Chester have improved the original construction which consisted of cascade aerators, coagulating-basin and rapid filters by adding preliminary aeration, preliminary chlorination, improved arrangements for adding chemicals and mixing them with water and reaction tanks designed to store a half hour's flow. These changes will result in great improvement, perhaps enough to meet requirements should they prove inadequate, treatment of the chlorinated filter effluent with activated carbon, will surely produce an eminently safe and agreeable water and one which will be equal in quality and appearance to one purified by long storage, chemical treatment and filtration. The residual chlorine in the effluent of the sand filter is approximately 5 p.p.m. during the half hour the filter is operated and the water is chlorinated. After standing one day, or just previous to the following day's operation, this has decreased to 1.5 p.p.m. During the two weeks that chlorinated water has been applied to the filters there has been a noticeable decrease in both the hot and tasted odor and the oxygen consumed value has decreased to 5.5 p.p.m. The residual chlorine of the water passing the carbon is approximately 0.05 p.p.m.

In conclusion, the speaker wishes to express his appreciation of the work of the authors in making available the results of experiments with water purification process, which while not new in fact is new in application.

CHARLES P. HOOVER:[8] It has sometimes happened, especially in the early days of water filtration, that new processes have been largely developed, their merits, short comings and applications determined by such men as Mr. Baylis and the other research workers who have taken part in this discussion on activated carbon here today and then after all of these contributions have become widely known, those desiring to use the process are rudely awakened to the fact that the cost of using the process, although not prohibitive, is unreasonably high, because of patent claims and royalties that must be paid.

I have not personally had an opportunity to study the patent situation regarding the use of activated carbon in water purification in detail, but it is my understanding based on information obtained from A. S. Berhman of the International Filter Company, that there

[8] Chemist in Charge, Water Softening and Purification Works, Columbus. Ohio.

is now no issued United States patent covering broadly the use of carbon in water purification and it is not likely that a valid broad patent of this sort can be granted, that is, whether the use of the carbon be of the carbon alone or as a dechlorinating agent following super-chlorination. This opinion is based on those portions of the United States patent law which stated specifically that no patent shall be granted if the idea in question:

(1) Has been described in any publication (either United States or foreign) more than two years before the date of filing the application for patent; or

(2) Has been in public use in the United States more than two years prior to the filing date.

The use of carbon of varying degrees of activity is much older than the two years required by law for the prevention of the issuance of any valid broad patent now; and the literature contains ample confirmatory evidence.

As a matter of fact, the use of a number of varieties of carbon for dechlorination following super-chlorination was patented by the Candy Filter Company, of London, England in two patents issued fifteen to twenty years ago; and the successful use of the method is mentioned in several references in the literature prior to 1920 in which a number of installations are enthusiastically described and indorsed by health authorities.

In view of these old British patents, and of the publications describing the successful use of de-chlorination with carbon, we do not see any possibility of the United States Patent Office issuing a basic patent covering broadly the use of carbon; or, if such a patent should happen to slip through the patent office, any possibility that such a patent could be sustained in the courts.

In addition to these British patents and publications, there has been public use in the United States of carbon for water purification for a great many years. For example boneblack has been used to remove tastes and odors, including chlorine, for at least ten years, and probably a good many more.

It is entirely possible that perfectly valid patents will be issued covering various details of apparatus or of methods of employing the carbon in water purification, but such patents, as we see it, will necessarily be improvement patents and will not make the process prohibitive because of patent royalties.

W. A. HELBIG:[9] Although Mr. Baylis discussed at some length the general characteristics of activated carbons in his paper at the Convention at Toronto last year, some further remarks on the properties of these carbons and their significance in the purification of water may be instructive in connection with the very excellent exposition of his later results which he has just presented.

As mentioned in the previous paper by Messrs. Behrman and Crane, these highly active carbons are not all alike. As a matter of fact, differentiated according to function they fall into two quite distinct classes, viz., gas adsorbent carbons and decolorizing carbons. The gas adsorbent type shows very little activity in the adsorption of coloring matter as ordinarily found in liquids requiring to be commercially decolorized regardless of whether such matter is actually in solution or in colloidal suspension. Conversely, the highly active decolorizing carbon evidences little adsorptive capacity in the gas phase though it will remove the aforementioned coloring matter from liquids very effectively. This then gives rise to the very interesting question "How can activated carbon of the decolorizing type remove from aqueous solution such large quantities of the gas chlorine, as Mr. Baylis' experiments have shown?"

Research work which has been carried out by the Darco Sales Corporation, with which I am associated, quickly led us to the conclusion that we are dealing here with a peculiar phenomenon which is rather different from a simple adsorption. Previous experience with analogous behaviour in other applications indicated that, in the presence of a somewhat similar carbon, certain reactions could be brought about which would either not occur at all or would go on at a much slower rate in the absence of the carbon. These results are not difficult to understand if we view adsorption as a force which draws into the pores of the carbon the adsorbed substances in much the same way as a capillary tube draws up a liquid to a height greater than that of the outside liquid in which it is immersed. Such a force would result in a concentraton of the adsorbed substance or substances within the capillaries of the carbon with a consequent acceleration of any reaction which might occur between the adsorbed materials. If now the reaction product is adsorbed to a lesser extent than the original materials we would expect the whole process to go on almost indefinitely provided no other factor enters. Thus, if in the present

[9] Chemist in Charge, Water Purification Division, Darco Sales Corporation, New York, N. Y.

case, we view the carbon as adsorbing some chlorine, and possibly some hypochlorous acid, we would expect two end products, viz., carbon dioxide, as a result of the combination of the oxygen from the unstable hypochlorous acid with some of the carbon, and hydrochloric acid. Mr. Baylis has previously described the evolution of CO_2 and the formation of HCl and we are well satisfied that the reaction proceeds according to the equation.

$$2\,Cl_2 + C + H_2O = 4\,HCl + CO_2$$

That the HCl and the CO_2 are relatively slightly adsorbed and that some such process as this actually occurs is proven by the fact that if we exhaust the chlorine adsorptive capacity of the carbon, that is, if we pass through it a chlorine solution at a given rate until the effluent shows chlorine, then stop the operation and allow the carbon to stand surrounded with the solution from which it has not adsorbed all the chlorine, after a period of time, depending upon various factors, the effluent will again be chlorine free and will show an increase in HCl upon resuming the flow of chlorine solution through the carbon.

It might be concluded that the equation previously given could be used to calculate the life of the carbon. Knowing the average residual chlorine content of the applied water, and the weight of carbon present, the quantity of water which could be treated could be calculated. In practice, such a calculation would be of little value, however, because of organic material in the water. In other words, the removal of various tastes and odors, phenols, algae tastes, the swampy taste of decomposed vegetable matter, etc., forces us to the conclusion that these materials are also adsorbed by the carbon and that they are oxidized in this adsorbed state much more effectively than when chlorine is just passed into the water without the carbon present. Here again the concentration of the organic matter and of the Cl and /or HO Cl in the pores or capillaries of the carbon must facilitate the reaction as otherwise we have no way of explaining the failure of chlorine alone to remove these tastes and odors. As a result of this oxidation of organic matter, it is plain that no calculation of the life of the carbon can be made from the equation given.

In conclusion, I might point out that this description of the mechanism by which an activated carbon like *Hydrodarco* operates in the purification of water, gives us a clue as to why a carbon of the decolorizing type rather than the gas adsorbent type is desirable for this purpose. Since the gas adsorbent carbon is not designed to

adsorb dissolved and colloidal organic matter from liquids, we do not obtain with it the concentration of these substances within the carbon capillaries that we do obtain with the decolorizing type of carbon. Consequently, we have the optimum condition for the indicated oxidation of organic matter only in the case of the activated decolorizing carbon, i.e., one which evidences high activity in the adsorption of such material.

E. B. SHOWELL:[10] In discussing Mr. Baylis' paper, the following experiences may be of interest to the Association.

The Dupont Company operates a plant situated on the Niagara River, a mile north of Buffalo. Water is taken from the Niagara River and purified by the usual mechanical filtration process, using alum with mixing, coagulation, filtration and filtered water storage. Most of the filtered and purified water is used for manufacturing purposes, but a small portion is supplied for drinking and is circulated through a separated drinking water system equipped with carbon filters, fountains, coolers, etc. It is the drinking water with which we are concerned.

The raw unfiltered water is highly contaminated with Buffalo sewage and pre-chlorination is practiced to prevent septic action in the coagulation basins and keep the bacteriological content at a minimum. The initial dosage of chlorine averages 0.81 p.p.m. of chlorine with maximum 6.2 and minimum 0.4. The dosage is controlled to maintain a residual of 0.25 p.p.m.—±0.05 in the filtered water. The drinking water is a portion thereof.

The employees complained of the chlorine taste imparted by the residual chlorine of 0.25 p.p.m., and six years ago activated carbon filters were installed for the purpose of removing the chlorine taste and for this purpose of dechlorination they have proved highly successful.

For the purpose of this discussion, the process may be considered one of super-chlorination and dechlorination by activated carbon. Considered from this standpoint, the removal of taste of chlorophenol origin and other tastes, the process has not been very successful. From time to time employees have complained to the management of the bad tastes in the drinking water and the situation became the subject of investigation. For approximately one year tastes were

[10] Water Supply Engineer, Engineering Division, The Dupont Company, Buffalo, N. Y.

studied and, although on numerous occasions they were so fleeting as to be impossible of investigation, there were other times when tastes were known to exist in the filtered water which were of sufficient duration to permit intelligent study. A record of these instances shows the following analysis during the period October, 1928, to October, 1929, in which period the situation received serious consideration.

Taste was noted in the filtered water, that is, influent to carbon filters, 301 times. Of these 301 occurrences, the water coming from the carbon filters was free from taste 164 times, or 54.5 percent. Seventy-three, or 24.3 percent of the taste was slight; 53 times, or 17.6 percent, the taste was bad; and 11 times, or 3.6 percent, the

TABLE 1

DATE	RAW WATER—CHLORINE DOSE, P.P.M.			RESIDUAL CHLORINE, P.P.M.				CHLOROPHENOL TASTE
				Before carbon filters			After	
	Average	Maximum	Minimum	Average	Maximum	Minimum		
1929								
January 2	1.85	2.25	1.20	0.23	0.30	0.20	0	Bad
January 3	1.55	2.00	1.25	0.24	0.30	0.20	0	Bad
January 4	3.11	4.00	0.60	0.24	0.30	0.20	0	Very bad
January 5	1.50	2.00	1.00	0.24	0.35	0.20	0	Very bad
January 6	1.39	2.00	1.00	0.23	0.35	0.20	0	Very bad
January 7	0.65	0.90	0.50	0.17	0.20	0.15	0	Bad
April 10	0.95	1.25	0.60	0.25	0.25	0.25	0	Bad
April 26	0.60	0.80	0.40	0.25	0.25	0.25	0	Very bad

taste was very bad. On some of the occasions the remaining taste was distinctly earthy.

The worst period experienced when a chlorophenol taste existed was January 3 to 7 inclusive, 1929. During this period the water was positively undrinkable, even after the carbon filters had been reactivated in an effort to make them more efficient. A similar period of very bad phenol taste was encountered on April 16 and 26, 1929.

Table 1 shows the chlorine dosage applied to the raw water and residual chlorine remaining in the filter effluent applied to carbon filter, during the periods when the chlorophenol taste was bad and of sufficient duration to permit study.

The chlorine dose was calculated hourly from difference in weight

and Venturi meter readings of flow. The orthotolidine method was used to test the residual chlorine at hourly intervals and as nearly as could be figured the contact period was approximately 150 minutes from the time it received the chlorine until it passed through the carbon filter.

A strong chlorophenol taste persisted in the water before and after passing the carbon filter, during the periods covered by the table. Chlorine was not present in the effluent from the carbon filters as shown by hourly test by the orthotolidine method.

This is not my idea of a taste-removing filter and I believe this method of carbon filtration is not applicable in this case. It may be the kind of carbon used and I would be glad to test samples of carbon and cooperate with Mr. Baylis in applying the carbons he has found successful in his experiments. Arrangements are being made to try other carbons and one known as 40-minute adsorbite carbon, 6–14 mesh, supplied by the American Solvents Recovery Corporation, Columbus, Ohio, is the next one scheduled.

It is possible that the carbon has become saturated with the taste producing compounds which are not driven off during revivification by the steaming method. If this is the case, the use of carbon for taste removing has distinct limitations. To be of practical use the material must be revivified in the bed and the development of chemicals for this purpose has possibilities, but may prove different for different taste saturation. Removal from the bed and heating to fairly high temperature seems to limit its use to small size installations. In the case under discussion, it would be as cheap to replace completely by new carbon, as to remove, heat and replace.

DESCRIPTION OF THE INSTALLATION

The installation is composed of a set of four so-called "Twin Filters" which were purchased in 1924 from the Twin Filter Company, Inc., 74 Bradley Street, Buffalo, N. Y., who have since gone out of business. The filters are 12 inches inside diameter by 38 inches overall height, containing a 30-inch bed of boneblack through which the water passes in an upward direction. The boneblack, supplied by the R. T. Waddell and Company, 52 Beekman Street, New York City, who have since been taken over by the James H. Rhodes and Company, of Long Island City and Chicago, has the following analyses when new: Carbon, 9–10 percent; insoluble silicate, 0.15 percent; calcium sulphate, 0.06 per cent; calcium sulphide, 0.05 percent;

calcium carbonate, 8.90 percent; iron, 0.06 percent; undetermined (calcium phosphate), 81.78 percent; total ash, 84.4 percent. The size is 8–16 mesh. The carbon bed is supported between two discs of fine wire cloth made of silver coated copper wire. The wire cloth is the type used for filtration and runs 12 mesh one way, and 64 the other with 0.028 inch to 0.023 inch diameter wire respectively. The 4 units are connected in parallel by ½-inch piping to a 1-inch inlet and outlet header. The influent water is measured by a disc type meter.

The filters were originally connected in units of 2 in series, one containing quartz and the other carbon. Since the water applied is clear, the connections were altered to operate all 4 units in parallel, the water passing through carbon only.

The manufacturer rates each filter at 8,000 gallons per 24 hours, which gives the total capacity of 32,000 gallons per day for 4 filters.

TABLE 2

	GALLONS PER MINUTE	GALLONS PER SQUARE FOOT PER MINUTE	VELOCITY, FEET PER MINUTE	CONTACT, MINUTES
Average	2.51	3.2	0.545	4.59
Maximum	4.00	5.1	0.614	4.07
Minimum	1.96	2.5	0.425	5.88

This corresponds to 5.56 g.p.m. per filter, or approximately 7 gallons per square foot per minute, which corresponds to a velocity of 0.96 foot per minute, say one foot per minute, which gives a contact of 2.5 minutes with the carbon bed.

Each filter contains 1.96 approximately 2 cubic feet of activated carbon 40 pounds dry weight corresponding to a unit weight of 20 pounds per cubic foot.

OPERATION

The water flows upward through the carbon and the plant operates to take care of the make-up water required by the circulating drinking water system, which is automatically controlled by a float valve located in a cooling tank. The ratings over the past six years on a per filter basis are given in table 2.

These rates are much slower and the period of contact longer than the manufacturer's rating described above.

The filters are backwashed daily by reversing the flow.

Orthotolidine tests are made hourly on the water entering and leaving the carbon filters. Should a test show the presence of chlorine in the effluent, the filters are reactivated. If the presence of chlorine is not shown, the reactivating is done at monthly intervals. During approximately 6 years operation, chlorine has never been indicated in the effluent from the filters.

Reactivation is accomplished by admitting steam at top and discharging the hot condensate at the bottom. At first the waste water is cool and colored as the steam slowly heats the carbon mass. The discharge finally becomes clear and the condensate nearly at the boiling point. The reactivation is continued until the color disappears from the waste water and the apparatus has become as hot as the steam will make it. The time required for revivification is about 45 minutes.

The activated carbon has been replaced 90 percent since installation six years ago. The trouble is not with the carbon, but with the screens supporting it. The original wire cloth was of copper, which disintegrated under the conditions. Silver coated copper wire is now being tried with better success. When the wire cloth breaks some of the carbon is lost before the screen can be replaced. Were it not for the trouble with the wire cloth, the carbon losses would probably be very much less.

The old and new boneblack have been examined microscopically. The new boneblack is shiny and looks alive, the old has lost this luster and has a gray appearance similar to coke. The difference might be described as that between coal and coke. Photo-micrographs were made but the difference between the old and new carbon is not very well set forth by this method. A slight deposit was seen on some of the old grains, but the pores show little signs of clogging. The old boneblack examined under the microscope had been revivified 26 times.

As stated above, we are not through with the problem of taste removal and we have plans for trying other carbon and may go to chlorine ammonia treatment as the subject develops.

THE WATERWORKS OPERATORS OBJECTIONS TO BARE NEUTRAL WIRING[1]

By Chas. F. Meyerherm[2]

In a letter dated July 23, 1929, and addressed to Mr. A. R. Small, Chairman of the Electrical Committee of the National Fire Protection Association, the American Water Works Association definitely recorded its opposition to any sanction of Bare Neutral Wiring by the Electrical Committee. This action was taken primarily because it was felt that bare neutral construction, if adopted, would place electric power and light systems in the same class with the electric railway systems as sources of stray current on water main systems and, secondly, because the waterworks operators exercising supervision and control over all attachments to their piping systems felt that they should also speak for the unorganized water consumer in opposition to a method of electrical distribution which inherently tends to disseminate stray electric current to house piping and all other metallic structure systems in buildings with fire and other attendant hazards to life and property.

The waterworks operators appreciate the fact that in theory the neutral conductor of an electrical distribution system should carry only the unbalanced portion of the current in the other line conductors, but they also know that balanced electrical circuits seldom exist and with some types of electrical distribution there is no attempt made to balance the circuits. In portions or in most of the house wiring, therefore, the neutral conductor generally carries current which is of the same order of magnitude as the line current and which is changing constantly in magnitude and location of occurrence as lights or electrical devices in different parts of the building or in different buildings are turned on or off.

With appreciable current flow on a bare neutral conductor in a metallic conduit, paralleling gas and water pipes, or building metal

[1] Presented before the International Association of Electrical Inspectors, September 23, 1930. Reprinted here by permission because of its interest to our readers.—*Editor*.

[2] With Albert F. Ganz, Inc., New York, N. Y.

work will shunt off large or small portions of the neutral current depending upon the relative resistances of the shunt paths as compared to that of the neutral conductor. The hazard which always attaches to electric current flow over indeterminate metallic paths in buildings by way of pipes and metal structures which have not been designed to carry current depends, of course, directly upon the magnitude of the currents and potentials involved, but there is no assurance that under certain favorable conditions comparatively small currents and potentials cannot ignite explosive gas mixtures or kindle inflammable material nor set up corrosion or other damage along their paths. Furthermore, with shunt paths in parallel with the neutral conductor, there is no assurance that the continuity of this conductor will be continuously maintained, or that discontinuities will be readily located and eliminated. If neutral discontinuities are allowed to exist, the conduit with its customary uncertain joints and foreign metallic structures which are not intentionally made continuous electrical conductors will have to carry all of the neutral current. This is distinctly undesirable if not actually dangerous even under normal circuit load conditions, and it is infinitely worse under short circuit conditions when the current flow over foreign structures may attain values far in excess of the safe carrying capacity of these structures or of the metallic contacts between them and the neutral conductor.

On the water main system, stray alternating current is distinctly objectionable from the standpoint of the operators of that system, not only because of the electrical and corrosion hazards which it may entail but because it so seriously complicates and confuses the direct current electrolysis test and mitigation program upon which continuity of service and pressure for normal and fire protection purposes often depend. It is, of course, freely admitted that alternating current interchange between a metallic structure as, for example, a water pipe and earth will not cause nearly so much electrolytic corrosion as the same amount of direct current leaving the pipe for earth. The point that gives waterworks operators concern, however, is that with present day electric light and power loads and the rapidly increasing electrical demand, the resultant alternating current corrosion, even though it is not so great as would occur with the same amount of direct current, may nevertheless be just as serious as present stray railway current electrolysis problems which are certainly troublesome and expensive enough.

Even with direct current, electrolysis trouble does not, as commonly supposed, involve hundreds of amperes or even tens of amperes, but is generally a matter of an ampere or less discharging from a main to earth. In the case of service pipes serious corrosion often occurs with current discharges in the order of hundredths of an ampere so that fractions of an ampere of alternating current may also prove troublesome. With alternating current, trouble can occur whenever and wherever local conditions are favorable, whereas with direct current, the areas where corrosion trouble is most likely to occur can be fairly accurately anticipated. Furthermore, alternating current conditions may be intermittent with irregular and indeterminable intervals and it may be superimposed upon a continuous or intermittent direct current condition so that testing and the application of remedial measures are complicated immeasurably.

With their stray current experiences in mind, the waterworks interests are considerably perturbed over recent trends in electric light and power distribution practice which would seem to indicate a tendency for the electric light and power industry to deliberately discard the very safeguards which kept them out of the railway stray current class, and which in the past have permitted, if not actually fostered, the rapid expansion of electric light and power service without serious hazard or damage to foreign utilities or private property. They would deeply regret the electric power and light industry taking any such backward step, and they would most respectfully urge that before material changes in distribution methods are adopted, careful consideration be given to all of the direct and indirect effects of such changes. If this is not done, supposed advantages may be more than offset by disadvantages which have been overlooked. In the case of bare neutral wiring, the waterworks operator can see only a comparatively insignificant saving in installation cost, which would not begin to compare with the hazard and expense that the electrical, neighboring non-electrical utilities or property owners may be put to as the result of the adoption of such a type of wiring. Waterworks operators, of course, have no authority to, and no intention of, dictating electrical distribution policies as such, but when these policies appear to involve life and property hazard to water consumers, waterworks employees or waterworks operators, they are obliged to act in the defense of their interests. They have consistently opposed any use of the

water piping system as a current carrying part of an electrical circuit and on this basis they oppose bare neutral wiring.

In conclusion, the writer on behalf of the American Water Works Association wishes to express his appreciation for this opportunity to present the waterworks' viewpoint on Bare Neutral Wiring before this convention and to thank the International Association of Electrical Inspectors for their courtesy in extending the invitation that made this possible.

PROGRAM FOR THE FINANCE AND ACCOUNTING DIVISION[1]

By Hal F. Smith[2]

Our chairman's report indicates that he is a little disappointed that we did not accomplish everything that he had hoped for. May I add, that if our aims are as high as they should be, we never will, but it does seem essential to establish a goal to be continually striven for, even though never reached. With this in mind I take the liberty of suggesting a goal and a means of arriving at it or at least a means of pushing on towards it. Looking back for a moment we realize that our Division was organized just one year ago and was naturally attended by the usual confusion of an organization meeting. No definite detailed method of procedure was formulated, nor is it fair to expect that it could have been in so short a time. That which has been accomplished is due to the conscientious efforts of our chairman, secretary, directors, committees and the enthusiastic support of the members. The fact that the membership of the Division has increased from the original 40 present at the first meeting to 490, is undeniable proof of the interest of the members of the Association in this Division.

It seems pertinent at this time to stop for a moment to take stock, and to carefully consider the duties and responsibilities that devolve upon us as a Division organized to deal with the finance and accounting methods, or in other words the business administration of water works. We first see an Association of 2895 members now holding its fiftieth annual convention in the interest of the advancement of knowledge of the design, construction, operation and management of water works. To better cover all activities of the industry, the Association is divided into three divisions; Water Purification, Plant Management and Operation, and Finance and Accounting. Al-

[1] Presented before the Finance and Accounting Division, the St. Louis Convention, and adopted by the Division at its regular annual business meeting, June 6, 1930.

[2] Head Water Consumers Accounts Clerk, Department of Water Supply, Detroit, Mich.

though our constitution does not specifically state, I believe that it was the intent that this Division should interest itself not only in accounting and finance, but rather in all activities relating to business administration. This interpretation seems necessary in order to consider our Association a well balanced organization that has provided for study and research of all the various activities of the industry. Without this interpretation some of the activities soon to be mentioned, would have no place in any division. If I am correct in the interpretation, then it seems that the work of this Division might well be divided into the following sections or committees:

1. Finance
2. General Accounting
3. Taxation
4. Office Management
5. Purchases and Supplies
6. Personnel
7. Public Relations
8. Legislation

Each section should be headed by a duly appointed chairman with authority to appoint the balance of his committee.

Under this plan one or more subjects would each year be assigned to each section, with instructions to bring in at the following annual meeting, a report of their study and research, together with recommendations that their conclusion as to definition, classification or method of procedure be declared standard. In case the Division cannot agree on a pronouncement at that time, the subject may, of course, be re-assigned or dropped.

It is obvious that subjects for assignment should be carefully considered as to the immediate desirability and practicability of standardization.

In a program of this kind the mere title of the section is insufficient, a statement defining the scope of each section is desirable. In full recognition of the fact that such statements should be the result of considerable study by persons particularly qualified to treat with each of the activities with which we are concerned, I have nevertheless prepared, for the purpose of illustration, such statements, as they seem necessary at this time to make clear the scope of the proposed committees.

1. Finance.

   Scope of Section. This section is to undertake the study of methods of providing funds for construction, operation, extensions and related needs of water works, together with studies of comparative costs of such financing based on methods in use at present or as developed in the future. This section is also to cover rate making and such other subjects as are naturally allied.

2. General Accounting.

   Scope of Section. This section is to cover all phases of general accounting as apply to water works and in coöperation with public utility commissions and such other societies and agencies as are deemed advisable to make such studies and present reports thereof that will tend to secure standardized practice for general accounting methods.

3. Taxation.

   Scope of Section not yet determined.

4. Office Management.

   Scope of Section. Forms, records and methods in office administration, customer accounting, meter reading, collections, etc.

5. Purchases and Supplies.

   Scope of Section. Purchasing methods, storekeeping methods, inventories, inspection of foods, price fluctuation, traffic management, etc.

6. Personnel.

   Scope of Section. Coöperating with existing technical societies and agencies and recognized authorities, through study, investigation and discussion, to formulate for action by the division, policies governing and standard methods for use in handling personnel problems of water works operation and administration in all its phases, including the selection and recruiting of new employees, promotions, layoffs and discharge policies and methods, the qualification and compensation of employees, maintenance of employee efficiency and morale through training and educational programs; recreational and health work, instruction in safety methods, sick leave and vacations, and such other phases as may be of interest or value to the industry.

7. Public Relations.

   Scope of Section. To make a study of ways and means of creating and maintaining customer good will through advertising, courtesy on the part of employees, handling complaints, extra service, public participation in securities of the company, etc.

8. Legislation.

   Scope of Section. To undertake the study of the relationship existing between legislative, quasi-legislative and other governmental agencies, national, state and local, with particular reference to such phases as public regulations and general legislative provisions governing the business and operation of water works.

This plan is submitted for your consideration and for such action as the division may care to take as a means of meeting the duties and responsibilities with which we, as a Division of the Association, are charged, and in the belief that it would eventually lead to our objective, a complete standardization of terminology, definitions, classifications, forms, and general practice relating to all the various activities with which this Division is concerned.

It is further suggested that all pronouncements made by this Division be referred to the Committee on Water Works Practice for ultimate review and release.

SHALLOW SEDIMENTATION BASINS[1]

By Wilfred F. Langelier[2]

Essentially, this paper describes the somewhat novel utilization of an existing pipe line and tunnel of the Marin Municipal Water District for the purpose of the clarification of its supply from Alpine Reservoir.

The present title "Shallow Sedimentation Basins" although perhaps somewhat misleading, was selected with a view to calling especial attention to certain features of sedimentation basin design to which it is believed this plant owes its remarkably high clarifying efficiency.

Alpine Reservoir was first placed in service in 1918 and was increased to its present capacity of one and one-half billion gallons in 1924. It was formed by the construction of a concrete dam across Lagunitas Creek, a stream draining the heavily wooded north slope of Mt. Tamalpais. Lake Lagunitas, about one-tenth the size of Alpine, lies higher up on the same stream. This is a much older supply and has been in use for about sixty years.

QUALITY OF WATER

The waters from both of these reservoirs are moderately soft and since the watersheds are uninhabited and their use for recreational purposes limited, the supplies need only the additional safeguard of chlorination to render them hygienically satisfactory. Bacteriological analyses made in the District's laboratory in 1928 showed that twenty-one percent of the Standard 10 cc. portions of raw water and six percent of the chlorinated water gave positive results for the presence of the colon bacillus as confirmed on a dye agar medium.

Physically, however, the waters from Alpine Reservoir fall short of that quality which may be supplied to consumers without causing excessive numbers of complaints. The discoloration of the water caused by vegetation extracts and eroded yellow clay soil is even

[1] Presented before the California Section meeting, October 25, 1929.

[2] Associate Professor of Sanitary Engineering, University of California, Berkeley, Calif., and Consulting Sanitary Engineer, Marin Municipal Water District, San Rafael, Calif.

more objectionable than the turbidity, which measured in terms of the standard silica suspension is quite low. The apparent color is normally about 30 p.p.m. and the turbidity 10 p.p.m., using A. P. H. A. Standards. For short periods in the run-off season the turbidity may reach 40 p.p.m.

The waters from Lake Lagunitas are much clearer than those of Alpine and if drawn from near the surface can be used without complaint at any season of the year. In common with many reservoir

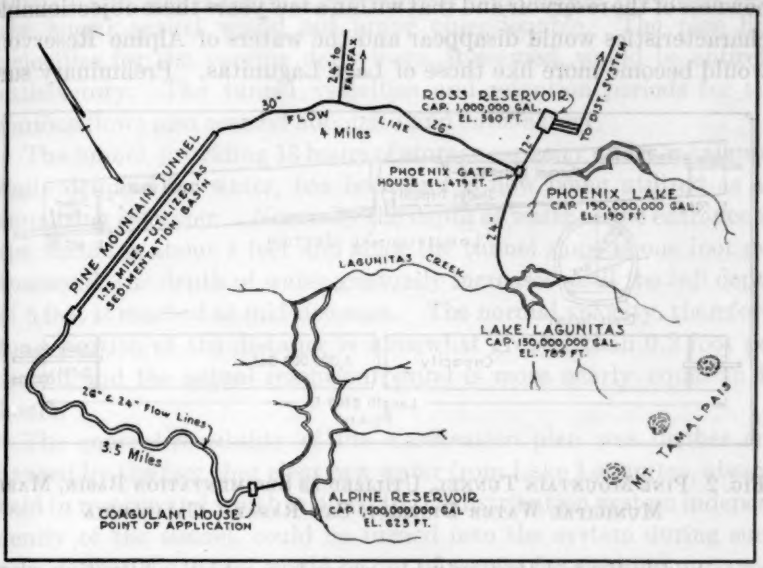

FIG. 1. DIAGRAM OF SOURCES OF SUPPLY, MARIN MUNICIPAL WATER DISTRICT, SAN RAFAEL, CALIFORNIA

supplies, the deeper water during a part of the year is devoid of oxygen and contains appreciable amounts of iron and to a lesser extent manganese salts.

Plankton or algal growths have never been a serious problem in either of these reservoirs. The normal volume of plankton is about two cubic centimeters per cubic meter of water, and consists mostly of common water fleas or Crustacea. Occasionally the growths attain a volume of 10 cc. per cubic meter, but tastes and odors from this cause have not been noted.

INSTALLATION OF ALUM DOSING TANK

The problem of investigating the Alpine supply with a view to formulating plans for its treatment was intrusted to the writer in the fall of 1927. Funds for the erection of a filtration plant were not immediately available, and, moreover, it was not certain that the cost of a complete treatment plant, comprising coagulation basins and filtration units, could be justified. There was a feeling that the discoloration and turbidity of the water were due to the comparative newness of the reservoir and that within a few years these objectionable characteristics would disappear and the waters of Alpine Reservoir would become more like those of Lage Lagunitas. Preliminary sur-

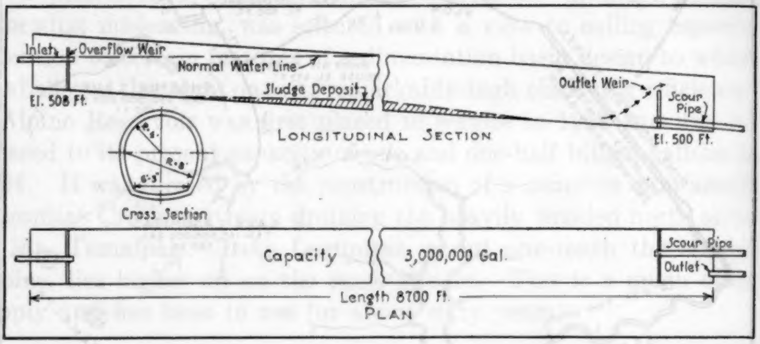

FIG. 2. PINE MOUNTAIN TUNNEL, UTILIZED AS SEDIMENTATION BASIN, MARIN MUNICIPAL WATER DISTRICT, SAN RAFAEL, CALIFORNIA

veys had indicated that suitable ground on which a filtration plant could be built at reasonable cost and which would function without the necessity of pumping, was not available.

The idea of coagulating the water in the pipe line from the reservoir and the utilization of Pine Mountain tunnel as a subsidence basin suggested itself as a temporary expedient, and without much delay plans to accomplish this were begun. Both structures seemed eminently suited for the purpose, and it seemed quite apparent that they could be used without detriment to their normal functions. The pipe line, three and one-half miles in length with curves and bends aggregating the equivalent of eighteen complete circles, would provide the agitation essential to coagulation, and the tunnel, 8700 feet long and of 50 square feet cross-section, should serve admirably for the purpose of subsidence. A check by computation showed that the

maximum six million gallon daily flow would cause a 2.5 feet per second velocity in the 26-inch pipe line flowing full, and a 0.2 foot per second velocity in the tunnel also flowing full. Corresponding retention periods would be 2 hours for the pipe line and 13 hours for the tunnel. The retention in the pipe line would be several times longer than the standard period recommended for coagulation, but to shorten the period would have meant locating the alum plant at a point too difficult of access and too far removed from the other activities of the operator. Laboratory experiments indicated that the longer period would not prove objectionable. The pipe line velocities for the varying daily flows, it seemed, would be entirely satisfactory. The tunnel velocities and retention periods for the various flows also seemed adequate and satisfactory.

The tunnel, providing 13 hours of storage capacity under maximum daily demand for water, has been and is now being utilized as an equalizing reservoir. Normally the depth of water at the entrance to the tunnel is about 4 feet and since the tunnel slope is one foot per thousand, the depth of water gradually increases until the full depth of 8 feet is reached at mid-distance. The normal velocity, therefore, for a portion of the distance is somewhat greater than 0.2 foot per second and the actual retention period is more nearly equal to 11 hours.

The general feasibility of the clarification plan was further enhanced by the fact that clear raw water from Lake Lagunitas, always held in reserve and which is piped to the distribution system independently of the tunnel, could be turned into the system during such periods that the tunnel would be out of service for cleaning purposes.

It was estimated that a suitable coagulant house, with provision for alum storage, solution tanks and feeding devices, together with the construction of an outlet weir at the lower end of the tunnel, could be built for about $2,000.

Laboratory experiments indicated that a two-grains-per-gallon alum dosage costing about $4.00 per million gallons of water treated, would be sufficient to treat the most turbid water. Accordingly, the plant was built and on December 29, 1927, was started in operation.

RESULTS OF OPERATION

Basing our opinion on the observations of several alum pre-treatments units, we had expected a considerable improvement in the appearance of the treated water. We were wholly unprepared, how-

ever, for what we found when the first samples were collected. At that time the raw water had a turbidity of 40 p.p.m. and an apparent color of 35 p.p.m., as nearly as could be estimated. The treated water taken from the lower end of the tunnel on the second and succeeding days of operation might readily have been classed by an inexperienced observer as perfectly clear and colorless. Actually its turbidity was 1.0 and its color 5 p.p.m.

The efficiency of color and turbidity removal far exceeded our expectations. We were still somewhat skeptical as to the period of time over which we might continue to expect such good results. There was the possibility that the sludge would build up quickly to a point where it would be carried over the outlet weir. Some fear was held that at a later date water fleas would make their appearance and would not be removed by the treatment. The answer to these fears is that the system has been in operation nearly two years and the results have been continuously as efficient and satisfactory as first noted.

At intervals of about seven weeks, the exact time depending upon the season of the year, the quantity of alum used, and the character of the water, the tunnel is cleaned. The cleaning operation is very simple and readily accomplished. The water is drawn down as far as practicable, the supply shut off, and the reserve supply from Lake Lagunitas is turned into the system. A sludge or scour valve at the lower end of the tunnel is opened and the sludge is diverted to a deep ravine near by. Removal of the sludge is accomplished by three squads of three sweepers each, assisted by a gravity flush of water from the pipe line, admitted at the rate of about one cubic foot per second. About four hours are required and the cost is probably no greater than would be the case in cleaning a basin of similar capacity and of usual design. The deepest sludge is encountered at a point about midway from the ends. At this point it averages about eight or ten inches deep. A thin layer or carpet of sludge of decreasing thickness forms from about the two-thirds point on to the lower end.

CONCLUSIONS

We are quite satisfied that in the utilization of this tunnel as a sedimentation basin for coagulated water the results obtained are far superior to those which could be reasonably expected from the use of the usual type of basin of the same retention period, but of greater depth and breadth.

We are of the opinion moreover that, in general, long, narrow and shallow basins are likely to prove most efficient. For equal retention periods, basins of these proportions provide proportionately greater floor and surface areas, a minimum of so-called dead space, and are likely to result in shorter periods of turbulence at the turns, if any are provided. The desirability of each of these conditions can be supported by purely theoretical reasoning. Of even greater importance, however, in the writer's opinion, is the fact that in a basin of these proportions each particle of floc has a several-fold greater opportunity to collide with a surface, either bottom or side walls, become entrapped thereon, and consequently be removed from the water.

The limiting horizontal velocities which will cause objectionable movement of the deposited floc or sludge, although considerably greater than is generally believed, should not of course be exceeded. In the plant under consideration a velocity of 0.2 foot per second has not proven excessive.

We believe it is well to distinguish between installations of sedimentation basins for coagulated water where there is no further treatment of the water, and those where the water is subsequently filtered. In the latter case the removal of the last traces of floc is not necessary and by many it would be argued that it is not even desirable.

We believe, however, that many situations exist where shallow baffled basins, open flumes or conduits or even enlarged pipe sections could be used successfully and most economically for the clarification of water with the use of a coagulant, either with or without the aid of sand filtration.

COMPARISON OF THE DOMINICK-LAUTER PRESUMPTIVE TEST WITH "STANDARD METHODS" TEST FOR BACT. COLI IN WATER

By Harold W. Leahy[1]

It has long been recognized that standard lactose broth gives many fallacious gas formations due to lactose fermenting organisms not belonging to the colon group, and to symbiotic and synergistic combinations. An examination of the daily tests made on the Rochester City water has confirmed these findings of others. During the years 1928 and 1929 lactose broth presumptive tests for *Bact. coli* have failed to confirm in 51.5 percent of all samples tested, and for the period between January 1, 1930 and May 1, 1930 this failure to confirm has been 100 percent.

In order to be certain of the presence or absence of *Bact. coli* in the positive standard lactose tube, it is necessary to make a confirmatory test that requires from 48 to 96 hours longer. This method of water analysis takes from two to six days and is much too long for the test to be of immediate value to the sanitarian. It would seem advisable, therefore, to find a medium giving more reliable results with a shortening of the length of time now necessary for the examination of water. These conditions appear to be satisfied by the new methylene blue bromocresol purple medium of Dominick and Lauter (1).

A comparison of this new medium with standard lactose broth has been made on 300 samples of water from 91 different sources. The results show that approximately the same number of positive isolations can be obtained by either medium, and as will be shown later, the new medium gives a much higher percent of confirmation.

EXPERIMENTAL

Procedure for the comparison. The method of comparison for most water samples consisted in inoculating three 10 cc., three 1 cc., and three 0.1 cc. quantities of the suspected water into a corresponding

[1] From the Rochester Health Bureau Laboratories, Department of Bacteriology, School of Medicine and Dentistry, University of Rochester, Rochester, N. Y.

number of tubes of the standard lactose broth and the Dominick-Lauter medium. On waters known to be of good sanitary quality, five 10 cc. and three 1 cc. tubes were used. In cases of highly polluted samples, greater dilutions were made in order to insure that the last dilution be negative. The tubes were then incubated from 24 to 48 hours, and as soon as gas was formed in any of the tubes *all* gas positive tubes, regardless of dilution, were carried through the complete confirmatory test as outlined in Standard Methods (2).

Eosine methylene blue medium was used as a means of isolation; two typical colonies from each plate being transferred to agar slants and standard lactose broth tubes. The formation of gas in the standard lactose broth tubes and the demonstration of gram negative non-spore-forming bacilli in the agar cultures were considered as positive confirmatory tests. If such an organism failed to materialize, the tests were considered negative for *Bact. coli*.

Preparation of media. The standard lactose broth, eosine methylene blue and plain agar were prepared according to Standard Methods (2).

The new medium was prepared as directed by Dominick and Lauter (1) with the slight modification recommended in a communication from J. F. Dominick. The corrected formula as used in this work is as follows:

	grams
Lactose	10
"Bacto" peptone	10
"Bacto" beef extract	5
$K_2HPO_4 \cdot 3H_2O$	14.3
KH_2PO_4	2.0

This was dissolved in 2 liters of distilled water at a moderate temperature (50°–60° C.) and when dissolved there were added:

	cc.
1.6 percent alcoholic solution of bromocresol purple	4
1.0 percent aqueous solution of erythrosine	4
1.0 percent aqueous solution of methylene blue	20

For the 10 cc. inoculations of suspected water the above medium was tubed in 15 cc. quantities, for but the smaller dilutions 600 cc. of neutral water were added to a one liter batch of the above and tubed in 15 cc. quantities. The medium was then sterilized at 15 pounds for 15 minutes. For pure culture work 666 cc. of neutral

water should be added to one liter of the original batch. The pH of this medium was determined electrometrically with a quinhydrone electrode and found to be pH 7.2.

In order to become familiar with the reaction of the new medium, a few tubes were inoculated with known strains of *Bact. coli.* In table 1 are shown the results of these preliminary inoculations with four stock strains of *Bact. coli.* As can be seen from table 1, there is a color change preceding gas formation that in some cases occurs as early as 12 hours. This yellow to orange-red color combined with the large amount of gas formed is the typical reaction of the new medium to the growth of *Bact. coli.* A larger amount of gas is produced in the new medium than in standard lactose broth, which

TABLE 1

Typical reactions of bact. coli in the Dominick-Lauter medium

BACT. COLI STRAIN NO.	12 HOURS		18 HOURS		24 HOURS		48 HOURS	
	Color	Per cent gas	Color	Per cent gas	Color	Per cent gas	Color	Per cent gas
11	Blue	0	Yellow-orange	1	Yellow-orange	50	Yellow-orange	50
12	Sl. yellow	0	Yellow	2	Yellow	50	Yellow-orange	50
13	Blue	0	Yellow	0	Yellow	50	Yellow-orange	50
14	Sl. yellow	0	Yellow-orange	2	Yellow-orange	50	Orange-red	50

might indicate the ability of *Bact. coli* to utilize the lactose in the new medium to a greater degree than in standard lactose broth.

The comparisons of Dominick and Lauter (1) were apparently limited to four types of water all from the same source. Since it is quite well known that waters vary as to their content of gas forming organisms not belonging to the colon group, it seemed advisable to make the comparison on as many different sources as possible. This was easily accomplished by using the samples that came to the Rochester Health Bureau Laboratories for examination; a few additional samples of well, river, and creek waters being gathered from the surrounding country. In this way the total of 300 samples of water from 91 different sources was obtained.

On comparison it was found that a much higher percent of gas

positive tubes were formed in standard lactose broth than in the new medium, but, on attempting to confirm these tubes, it was found that a slightly greater number of positive confirmations were obtained from the new medium than from the standard lactose broth. From the results tabulated in table 2 it is seen that of the 602 gas positive lactose tubes only 220 or 36. 5 percent were confirmed, while from the

TABLE 2

Comparison of standard lactose broth (2) with Dominick-Lauter medium (1)

	STANDARD LACTOSE BROTH			DOMINICK-LAUTER MEDIUM		
Total samples tested	300			300		
Total sources examined	91			91		
	10 cc.	1 cc.	0.1 cc.	10 cc.	1 cc.	0.1 cc.
Number of tubes made	1024	936	594	1024	936	594
Number of tubes gas positive	410	140	52	133	90	27
Number of tubes positively confirmed	118	68	34	126	80	26
Per cent of tubes confirmed	28.7	48.5	65.3	94.7	88.8	96.2
Total number of gas positive tubes	602			250		
Total number of confirmed tubes	220			232		
Per cent of all tubes confirmed	36.5			92.8		
Total *samples* gas positive (presumptive test)	182			49		
Total *samples* confirmed	49			49		
Per cent of all samples confirmed	26.9			100.0		

Total number of samples positive by both media........ 46
Total number of samples negative by both media........ 248
Total number of samples showing disagreement........ 6
Samples that were standard lactose broth (+) Dominick-Lauter (−)...3
Samples that were standard lactose broth (−) Dominick-Lauter (+)..3

250 gas positive Dominick-Lauter tubes 232 or 92.8 percent were confirmed. It is also seen that of the 300 samples of water tested in only six samples or 2 percent was there disagreement. Of these samples three were positive using standard lactose broth and negative using the new medium, while three other samples were positive by the new medium and negative using standard lactose broth.

Another point of interest brought out by these comparisons is the fact that when the percent confirmation is correlated with the dilution

it is found to increase with the dilution in the case of standard lactose broth but remain approximately the same for the new medium. This agrees with the fact found by other workers that the percent confirmation for standard lactose broth is greater on polluted waters than on relatively pure waters.

From the results tabulated in table 2 another and more important point is noticed. Out of the 182 *samples* that showed gas by standard lactose broth only 49 or 26.9 percent were confirmed, while of the 49 *samples* that showed gas by the new medium 49 or 100 percent of samples were confirmed. This fact would indicate that the new Dominick-Lauter *presumptive test* is not only equivalent to the Standard Methods' *completely confirmed test*, but has the added advantage of requiring at the most only 48 hours as compared with the 2 to 6 days necessary for the Standard procedure. This fact combined with the other facts cited above is sufficient to make the new Dominick-Lauter presumptive test far superior to standard lactose broth for the detection of *Bact. coli* in water.

SUMMARY AND CONCLUSIONS

1. Three hundred samples of water from 91 different sources have been tested by means of Standard Methods of Water Analysis and compared with the new Dominick-Lauter presumptive test (1).

2. It has been shown that the same number of positive samples could be obtained by either method, but that the percent confirmation was much higher for the new medium than for standard lactose broth.

3. It has been pointed out that the percent confirmation for standard lactose broth increased with the dilution, whereas the percent confirmation for the new medium remained approximately the same.

4. It has also been shown that of the total samples showing a positive presumptive test, 100 percent were confirmed for the new medium while only 26.9 percent were confirmed for standard lactose broth.

5. The new Dominick-Lauter medium was found to be far superior to the standard procedure for the detection of *Bact. coli* in water.

REFERENCES

(1) Dominick, John F., and Lauter, Carl J.: Methylene Blue and Brom Cresol Purple in Differentiating Bacteria of the Colon-Aerogenes Group. J. Am. Water Works Assn., 21: 1067–75, 1929.

(2) American Public Health Association. Standard Methods of Water Analysis, 6th ed., 1925.

OPEN RESERVOIRS AND THE SANITARY CONTROL OF TAP SAMPLES

By C. Leroy Ewing[1] and Edward S Hopkins[2]

The water supply of the City of Baltimore is controlled bacteriologically by the Water and Health Departments. The bacteriological laboratories of these two departments have demonstrated that through effective coöperation it is possible to obtain comparable results in different laboratories examining samples of water from the same sources. The coöperative work was started in September, 1926, and has continued without interruption since then.

In July, 1896, the bacteriological laboratory of the Health Department began the routine examinations of city "taps." These samples were collected at irregular intervals and examined for total bacterial counts and for the presence of the colon bacillus. Samples were collected in the beginning from stores and residences and later from fire engine houses. The tests for the detection of colon bacilli consisted in 1896 of examining 1 and 50 cc. quantities of water. Later, multiple amounts were tested, usually consisting of 10, 1, 0.1 and 0.01 cc. portions.

The laboratory of the Water Department began sampling of services as a routine procedure on May 5, 1925. This consisted of examining samples from fire plugs and "dead ends." On December 7, 1926, this procedure was changed to the sampling of "taps" from fire engine houses and was identical to that of the Health Department. In September of that year the stage was set for the beginning of the coöperative work.

A comparison of the results of previous years and those obtained monthly up to and including September, 1926, revealed the fact that there were marked differences in the percentages of confirmed B. coli as obtained in each laboratory. Because of this fact it was decided to get together for the purpose of standardizing the collection of samples, method of analysis and materials used in the bacteriological

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tests. As a result the methods which are used at the present time were adopted.

SAMPLING

The tap samples were collected by both departments on the same day, but not at the same time, from the various fire engine houses after flushing the line for five minutes at a moderate rate of flow. These samples were returned promptly to the respective laboratories. The Health Department samples were iced during transit. Those of the Water Department were uniced. The average time of transportation did not exceed four hours. In connection with the sampling there was not more than an interval of an hour or so between collections.

One sample per week was collected from each tap and reservoir as routine control practice. Samples of plant effluent were collected at six hour periods each day. The reservoir samples were taken just below the surface at a point about 6 feet from shore by using a pole to which a carriage had been attached to carry the sterile bottles.

METHODS OF TESTING

By January, 1927, both laboratories had adopted the confirmed Bacillus coli test, expressed in percentage of tubes tested, as recommended by the Committee on Water Standards in Public Health Reports (3). Concerning materials, media, etc., the Standard Methods of the American Public Health Association (4) were followed very closely.

As a result of the standardization of methods it was found that when the same sample was examined in both laboratories identical results were obtained. However, when the respective departments sampled and examined routine samples separately marked differences were obtained. This was indeed baffling. It was noticed however that the results of the Health Department usually gave higher percentages of confirmatives for B. coli, especially during the summer months, than those of the Water Department.

After ascertaining that the work as carried out in both laboratories was being performed on a comparable basis the question of sampling was again taken up. As mentioned before, samples collected by the inspectors of the Water Department were not iced, while those obtained by the Health Department were. The ice and ice water as carried in the cases by the Health Department inspectors were examined. The colon bacillus was found on several occasions.

Bottles of sterile distilled water were given to the inspectors to be carried in their cases during the collection of the routine tap samples. These samples were examined along with the routine samples, and were found to contain varying amounts of colon bacilli. This revealed the fact that it was possible to contaminate sterile water with ice water which had melted from the ice in the cases. As a result of this investigation the icing of samples was discontinued by the Health Department in July, 1929. Since that time both laboratories have been checking very closely. By referring to figure 1 A one can see the percentage confirmatives for B. coli as obtained in both laboratories from 1925 to June, 1930, inclusive.

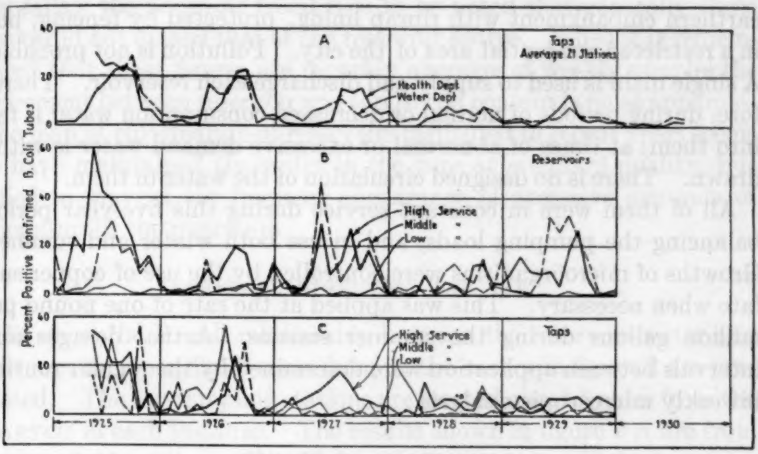

FIG. 1

As a result of this coöperative control it became of interest to learn the cause of the increase in B. coli at infrequent intervals in the tap samples.

Weekly bacteriological samples are collected from the reservoirs used to balance the pumping loads of the distribution system and from twenty-one places in the city, covering all services. The water in the low service area is obtained directly from the filtration plant; in the middle service it is pumped to a balancing reservoir, and in the high district it is repumped to a second balancing reservoir, being drawn from an intermediate one. A comparative study of the conditions of these samples gives, therefore, a definite picture of bacterial conditions in the water as delivered to all parts of the city.

DESCRIPTION OF RESERVOIRS

The three high service reservoirs were used for the study. Pimlico, of 26 million gallon capacity, has earthen embankments protected by a riprap lining; Towson, of 15 million gallons, is built of concrete with straight walls, and Pikesville, of 20 million gallons, has earthen enbankments, but lined with concrete. These reservoirs are above the level of their surrounding territories, and are located in either an isolated section of the city or a park, with slight possibility of accidental pollution. Two middle service reservoirs were utilized, Ashburton, of 195 million capacity, and Guilford, of 30 million. These basins are below the surrounding territory on one side, and are of earthern embankment with riprap lining, protected by fencing, but in a restricted residential area of the city. Pollution is not probable. A single main is used to supply and discharge each reservoir. Therefore, during periods of normal or decreased consumption water is fed into them; at times of abnormal or excessive demand water is withdrawn. There is no designed circulation of the water in them.

All of them were in constant service during this five-year period balancing the pumping loads, and in use both winter and summer. Growths of microörganisms were controlled by the use of copper sulfate when necessary. This was applied at the rate of one pound per million gallons during the summer seasons. Actual dosages and intervals between application were determined by the regular routine biweekly microscopic analysis.

COMPARISON OF RESULTS

A recent report of the Committee on Water Supply of the American Public Health Association (1) calls attention to the high B. coli content of tap samples remote from the source of supply. A more or less detailed statement from fourteen cities is given in which it is easily seen, in the majority of instances, that the increase reported came from open reservoirs in the distribution system. The B. coli content of the tap samples as shown by the curves in figure 1 C is of interest in this respect. Except for three instances it has not exceeded the permissible standard (10 percent of tubes tested) since 1926. This characteristic was not true prior to that year. Similar curves in figure 1 B, from the reservoirs, show B. coli to be in excess of the standard quite often during that period. It will be noted that the B. coli content of the plant effluent was not above 5 percent.

A study to learn the relationship of these conditions to the general supply was undertaken. Since the curves show average figures from all samples collected in either the reservoirs or taps of a given service, they are representative of it.

Ignoring variations below 10 percent, an inspection of the curves discloses that only about one-half of the total tests in excess of the standard occur simultaneously in the taps and reservoirs, and that the B. coli content of the reservoirs was often above this value without being directly reflected in the tap samples served by them. This is particularly true since 1926, while previous to that time the tap curve followed fairly closely the trend of the reservoirs. When a tap curve did follow the reservoir trend it is to be noted that generally these peaks did not exceed that of the reservoir source. When it is remembered that these figures are monthly averages of weekly samples the agreement between reservoir and tap B. coli content is quite apparent. The plan of chlorination of reservoirs instituted in recent years seems to have maintained the water in the taps at standard quality, but failed to prevent the frequent appearance of excessive amounts of organisms in the reservoirs.

SEPARATE RESERVOIR AND TAP

To show the B. coli relationship between the reservoir water and that in a tap on a direct main from it, the curves in figure 2 are presented. The tap sampling stations are located about 5 miles from the reservoir in each instance. The results shown in figure 2 A are from the small 15 million gallon high service reservoir which fluctuates violently during the heavy pumping period of the summer months, varying from being completely filled to a loss of 3 to 5 feet daily. At first glance little relationship between the B. coli above 10 percent in the tap sample and in the reservoir is noted. Careful analysis shows however that many of the peaks showing in the tap curve agree with similar periods of excessive coli in the reservoirs. In some instances they may be in excess. Also about 30 percent of the tap peaks do not have a complementary increase in the reservoir. This indicates that increased velocities in the main due to excessive use of water have disturbed the slime coating, throwing the bacteria living there into the system.

It can be definitely said, therefore, that under a condition of fluctuating water levels excessive B. coli in the taps is obtained directly from

the reservoirs or indirectly from previously seeded slime in the pipe lines.

The curve in figure 2 B from the 195 million gallon, middle service reservoir tells a different story. This basin even under condition of severe pumping does not fluctuate more than 4 to 6 inches daily. B. coli is often present in excess of 10 percent. The tap supply from it did not exceed the standard at any time during the five year period of the study. Such a condition tends to confirm the hypothesis advanced, namely, that, although extensive pumpage with resulting main disturbance occurred in this service, yet, since it was not seeded

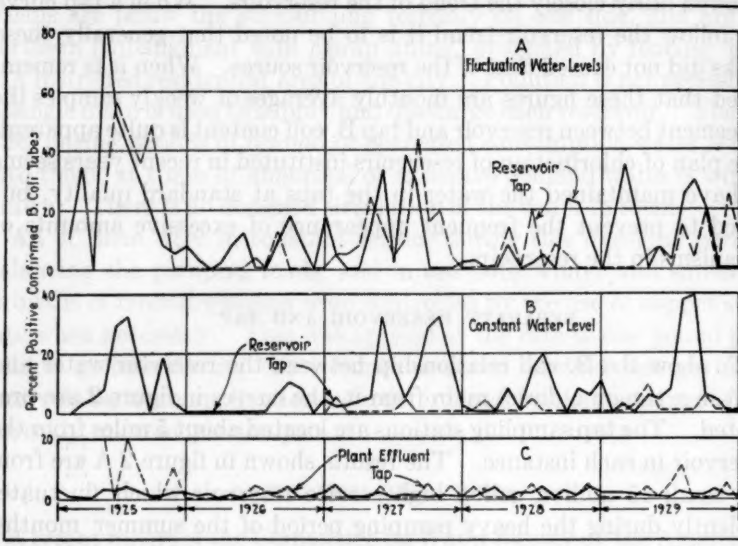

FIG. 2

with bacteria from the reservoir excessive organisms were not obtained when the slime coating was disturbed.

As a further confirmation of this hypothesis it will be noted that the peaks above 10 percent in both reservoirs occurred from about May to October each year, or only during the hot weather period. The curve in figure 2 C gives additional information. This is a comparison of the quality of the plant effluent as delivered to the low service area with that of a tap. Only two excessive tap conditions are noted, one in the service of 1926 and the other in 1929. A review of past records in the distribution division indicates these to be due to main

disturbances. There appears to be slight relationship between the water as delivered and that found in the taps corresponding to a B. coli content of less than 10 percent in that the curves do not coincide This is to be expected since the low service curve is the monthly average figure of the regular 6 hourly plant control samples and the tap curve a similar average from weekly tests. The ratio of tubes tested per month is about 250 to 25. If extensive bacterial growth was occurring in the mains, peaks conforming to that observed in the high and middle services would be obtained. This curve shows conclusively that such is not the case, and it also shows that *the contamination in the other services is due to open reservoirs.*

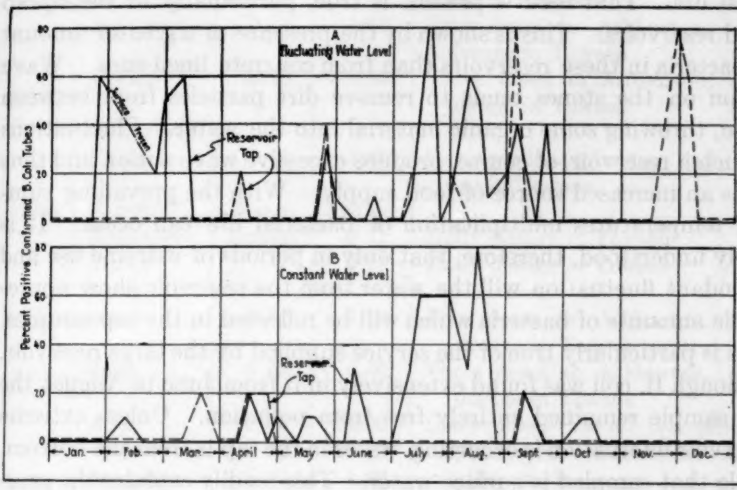

FIG. 3

To establish the point of reservoir contamination more clearly a study for the year 1929 was plotted, using these reservoirs and single samples from taps on a weekly basis. Two standard samples were used for testing the reservoirs and one for the taps. This makes the curves somewhat disproportionate since a single tube in the tap samples showing B. coli will give a figure above the standard. In comparing these trends this must be remembered and allowance must be made. Comparing the curves in figure 3 A it is clearly shown that violent fluctuations of the reservoir with attendant increase in B. coli were reflected in the tap samples. The slight fluctuation and therefore surface contamination only of the large

reservoir was not reflected in the tap samples when a ratio of 2:1 is considered for the same degree of pollution. The excessive B. coli content in November, 1929, in the tap of figure 3 A was found upon investigation to have been caused by main disturbances.

SEASONAL VARIATIONS

The general curve in figure 1 B and the specific curves in figures 2 A and 2 B show that considerable increase in B. coli occurs in the reservoirs from about May until September each year. This is due to at least two possible causes. The temperature of the water at this time of the year is about 68°F., and if food is present it will support bacterial life. That food is present is true, particularly in the riprap lined reservoirs. This is shown by the presence of a greater amount of bacteria in these reservoirs than from concrete lined ones. Wave action on the stones tends to remove dirt particles from between them, throwing some organic material into the water. Fluctuations of such a reservoir, of course, produce excessive wave action and thus gives an increased source of food supply. With the prevailing summer temperatures multiplication of bacterial life can occur. It is easily understood, therefore, that only in periods of extreme use and attendant fluctuation will the water from the reservoir show appreciable amounts of bacteria which will be reflected in the tap samples. This is particularly true of the service supplied by the large reservoir. Although B. coli was found extensively in it from June to August the tap sample remained entirely free from pollution. Unless extreme reservoir fluctuation is occurring, water in the tap is from the bottom, while that sampled is surface water. This readily explains the presence of excessive B. coli in the reservoir samples in hot weather, when it is sufficiently warm to support bacterial life and contains organic material from dead algae or plants. The general tap B. coli curves in figure 1 C tell a different story. From 1925 to 1927 peaks occurred in hot weather. In 1928 they were present in only April and November, believed due to abnormal main installations, particularly in the area supplied by the fluctuating reservoirs. In 1929, due to the application of sufficient chlorine to the secondary reservoirs, an increase of B. coli above the standard is not noted. The low service taps prove this readily, for at no time since 1927 have they exceeded 10 percent, or has the supply of this area increased.

TABLE 1

Total amount of chlorine (p.p.m.) applied per month to reservoirs in form of calcium hypochlorite

YEAR	MONTH	RESERVOIRS		
		Ashburton	Towson	Remarks
1925		None	None	
1926	December		.0.13	One dose
1927	May	0.04	0.20	One dose in each reservoir
	June	0.12	2.00	Two doses in Ashburton, daily dosage in Towson
	July	None	2.00	Daily dosage in Towson
	August	0.06	6.8	One dose in Ashburton, daily dosage in Towson
	September	0.12	4.80	Two doses in Ashburton, daily dosage in Towson
	October	0.18	4.00	Three doses in Ashburton, daily dosage in Towson
	November			
	December	0.06	2.80	One dose in Ashburton, daily dosage in Towson
1928	January	Frozen	Frozen	
	February	Frozen	0.72	Daily dosage in Towson
	March		0.28	Daily dosage in Towson
	April			
	May	0.31	4.00	Five doses in Ashburton, daily dosage in Towson
	June	0.18	4.00	Three doses in Ashburton, daily dosage in Towson
	July	0.61	4.00	*Daily dosage in all reservoirs in system* (proportionate amount of this total)
	August	0.92	4.00	
	September	0.92	4.00	
	October	0.92	6.00	
	November	0.92	6.00	
	December	0.92	4.00	
1929	January	0.61	2.00	
	February	0.61	2.00	
	March	0.61	3.20	
	April	0.61	2.00	
	May	0.77	4.00	
	June	0.92	5.60	
	July	1.23	8.00	
	August	2.15	11.20	
	September	2.15	12.00	
	October	1.80	10.00	
	November	2.15	8.00	
	December	1.38	4.00	

CHLORINATION

The decrease in B. coli as shown by the tap curve since 1926 is due to two phases. An increase in residual chlorine leaving the plant has been established and a definite system for chlorinating the reservoirs has been instituted. Table 1 using two reservoirs presents this in detail.

This plant residual chlorine has been possible without taste, and this is also true for the reservoirs, except in the case of the very high dosage of Towson, where a faint taste was reported.

A review of these figures is significant. They show clearly the reason for the decrease in the B. coli content of the tap supplies. That bacteria will live, but remain dormant in the slime of mains for an extended period is indicated in the work of E. N. Ballantyne (2), who, using dilutions of pure cultures, found B. typhosus living after

TABLE 2

Monthly average residual chlorine (p.p.m.) in plant effluent

YEAR	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	AVERAGE
1925	0.08	0.06	0.04	0.02	0.04	0.03	0.01	0.03	0.08	0.17	0.11	0.09	0.06
1926	0.07	0.07	0.08	0.08	0.07	0.03	0.03	0.07	0.06	0.21	0.12	0.11	0.10
1927	0.10	0.11	0.08	0.11	0.12	0.09	0.06	0.07	0.06	0.21	0.12	0.11	0.10
1928	0.13	0.10	0.13	0.09	0.10	0.11	0.11	0.14	0.16	0.18	0.19	0.25	0.14
1929	0.10	0.08	0.12	0.10	0.08	0.07	0.07	0.07	0.14	0.20	0.14	0.13	0.11

100 days in distilled water. This characteristic of long life under such conditions was found to be true of other organisms including B. coli. Room temperature was found to be favorable for such survival.

The increase noted prior to 1926 certainly supports this theory, together with the occasional outbreaks since then. It is apparent that insufficient residual chlorine has an important bearing, and that an initial residual of at least 0.10 p.p.m. after two to four hours contact is necessary to prevent multiplication of coli during warm weather in this water. It should be remembered that the source of these organisms is not from improper filtration, but accidental contamination of mains, new installations, etc., or from open reservoirs. The daily chlorination of the reservoirs has been of value. B. coli in excess of the standard has not been present in any of the tap

samples since it has been instituted. It appears from this study that the present daily dosage of chlorine to the reservoirs should be increased in the summer season to reduce the B. coli content in the surface water. This can not be done without creating a taste condition.

The use of chloramines in this connection deserves additional study. If a cheap, practical method of applying and controlling them can be made available, then treatment with such a compound will be possible and will permit increased chlorine dosages to be utilized without the danger of taste complaints.

Is such control of value? We believe so. Inspection of the general tap curves in figure 1C proves the value of secondary reservoir disinfection except under conditions of violent fluctuation. When this occurs tap samples contained the excessive amount of B. coli as found in the reservoirs.

The sanitary significance of the presence of B. coli under such conditions appears to be of little merit. Yet, if bacteria, even though harmless, are growing in an open reservoir, particularly during warm weather, that, from a possible accidental pollution, could be harmful and cause serious trouble. A policy that will give sterile water to all sections of a city by actual test, has a value far beyond its cost. The confidence of the citizens and health officials with their active support and coöperation creates a spirit that is much to be desired.

Appreciation is acknowledged of the assistance given by D. H. Goldsborough of the Distribution Division by his painstaking invesgation of the records concerning the many questions of main disturbances submitted to him, the faithful supervision of the routine bacterial analysis by S. E. Edwards and T. C. Buck, Jr., Senior Bacteriologists, and the coöperation of R. S. Craig, Director of the Bureau of Chemistry and Food.

REFERENCES

(1) Am. J. Pub. Health, 20: 485 (1930).
(2) E. N. Ballantyne, J. Bact., 19: 303 (1930).
(3) Drinking Water Standards, Pub. Health Repts., 40: 693 (1925).
(4) Standard Methods of A. P. H. A. (3), (1921).

REPORT OF SECTIONAL COMMITTEE ON CODE FOR PRESSURE PIPING FOR 1930

There has been little change made in the code for power piping as last published except for a few editorial corrections. At the December, 1929, meeting, it was unanimously moved to allow wrought iron bolts for pressures up to and including 125 pounds.

Sub-Committee 4 on Gas and Air Piping stated that the Code was in final form except for any changes or redrafting that might be necessary as a result of requests from the natural gas industry. They expect to have this work completed in time for the December, 1930, meeting.

Sub-Committee 5 on Refrigeration Piping reported that it is impossible to get any one in the refrigeration field to take any interest in the preparation of a Piping Code for this class of piping.

Some slight modifications in the Oil Piping Code were made including a section for higher pressures and temperature rating of 1500 pounds and 900°F.; also an amplification of cast iron pipe requirements (at the request of the cast iron pipe interests).

In regard to Piping Materials and Identification, Sub-Committee 7, the question of an appropriate identification mark is being considered. Nothing definite has been decided.

The committee is also considering a section on hangers, supports, and anchors. Very little has been done on this at this time.

F. N. Speller,
Chairman.

DISCUSSION

A Comparison of the Physical Properties of Various Kinds of Cast Iron Pipe[1]

The authors have made an interesting attempt to determine the relative service merits of six kinds of cast iron pipe of the 6- and 8-inch sizes. The authors describe the method of giving numerical ratings as follows: "In each of the tables whose data contributed to the rating in a direct way will be found a column of points. These points were arrived at by giving six points to the most desirable pipe in the test in question and one point to the least desirable and by computing the rank of the intervening four pipes on a proportionate basis." It seems that the method described above is open to objection. This may be shown by an example. First the tensile strengths of six hypothetical cast irons, designated as A, B, C, D, E and F, are compared using the authors' method for determining "points."

DESIGNATION	ULTIMATE TENSILE STRENGTH	POINTS
A	30,000	1.00
B	30,500	2.00
C	31,000	3.00
D	31,500	4.00
E	32,000	5.00
F	32,500	6.00

Now substitute another cast iron, A′, for cast iron A and again determine the points for each cast iron.

DESIGNATION	ULTIMATE TENSILE STRENGTH	POINTS
A′	22,500	1.00
B	30,500	5.00
C	31,000	5.25
D	31,500	5.50
E	32,000	5.75
F	32,500	6.00

[1] Journal, June, 1930, page 796.

Five of the irons are the same as in the preceding case, but the ratings have a very different relationship. It would seem more logical to make the ratings proportional to the tensile strengths.

The authors compute the bursting strength of a pipe by multiplying the tensile strength of the metal on the thin side of the pipe by the thickness on that side. This does not give "pounds per square inch internal bursting pressure" as table 4 is erroneously headed, but represents the tensile resistance per inch of length of one pipe wall. However, the ultimate tensile strength as calculated from bursting tests on full lengths of pipe have been found to be materially lower than the ultimate tensile strengths determined from tension tests on small specimens cut from the pipe. Further, the ratio of the ultimate tensile strengths determined by bursting tests to the ultimate tensile strengths determined from tension tests on small specimens is not the same for cast irons of different manufacture.[2] It seems, therefore, that not much weight can be given to bursting pressures calculated by the method used by the authors.

It seems incorrect to calculate the bursting strength of the Delavaud and sand-cast pipes by means of tensile strengths found several years ago on different pipe material than is used to determine some of the other ratings. The authors state "It will be noted that in the tests herein reported new Delavaud pipe was used for the radial compression and impact tests and that there was a notably higher resistance to radial compression and a greater relative deflection, both of which contributed to its higher standing in the present report." Since there has been a notable change, all of the tests should obviously have been made on the new material.

In determining the order of merit of the pipes with respect to variation in thickness, the average per cent of variation in thickness of wall around the circumference in each of the ten 18-inch lengths (only five measurements for sand-cast and five for Delavaud) is used. It is evident that the variation of thickness along the whole length of the pipe is of equal importance. Talbot and Richart's investigation shows that these variations may be considerable. According to the authors' method, a pipe would be reported as perfect in this respect if the thickness of each 18-inch length of the pipe were constant no matter what the variation of thickness along the length of the pipe.

[2] Proc. A. S. T. M., 26, Part II, 1926.

The greatest objection to the work of the authors is in their use of a few tests on a limited amount of material to establish the rating of competitive pipe. The authors' tests were made on ten specimens 18 inches long of each kind of pipe except that in the case of sand-cast and Delavaud only a few of the tests were made on the new material. It is not stated whether these ten specimens were cut from two lengths of pipe or from ten lengths, nor is it stated whether a specimen is from the bell end, the spigot end, or from an intermediate section. The elaborate investigation by Talbot and Richart on 6-inch cast iron pipe, referred to before, showed that there is a considerable difference in the results of the various tests on different lots of pipe from any given manufacturer. In their investigation each lot consisted of at least 12 lengths of pipe, three or more of which were subjected to bursting pressures, three to cross-bending, and three to impact, and the remaining lengths were retained for use in case it developed that further tests were needed. In all, more than 300 pipes were tested. A study of these comprehensive tests shows how inconclusive the results of a few tests would be, and this no doubt explains the inconsistency in the order of merit the authors assign to 6- and 8-inch pipe.

The usefulness of any numerical system for determining the relative service merits of different kinds of cast iron pipe is very doubtful. It is fallacious to assume that points may be given for various tests which can be added together to give the measure of service merit. An excess of merit in one respect can not be substituted for a deficiency in another.

The authors arrive at the following final conclusion: "However, from the general physical data which has been procured, the writers question the wisdom of recommending any vertical sand cast pipe, be it French or American." The average final rating of the vertical sand cast pipe is 105.9 out of a possible 110.0, which does not seem to bear out this conclusion, especially as it is stated that: "But due to the fact that all pipe passed specifications under which they were manufactured, and sold, it seemed that each pipe should receive a rating of 100 plus whatever it gained by reason of its relative performance in these tests. This in effect is equivalent to saying that any of these pipes will function to a degree that should satisfy the ordinary uses to which pipe were put."

M. L. Enger.[3]

[3] Professor of Mechanics and Hydraulics, University of Illinois, Urbana, Ill.

A Reply

It appears that Mr. Enger has misinterpreted the method of computing the ratings, for instead of computing them on a basis of most desirable 6, second most desirable 5, third most desirable 4 and so on down to least desirable with a rating of 1, we actually did grade them on a basis of their proportionate resistance just as he did in his illustration in which he substitutes cast iron A′ for cast iron A.

Table 4 as Mr. Enger points out is erroneously headed; it is a table in which the values shown graphically in figure 5 are arranged according to their rank. Table 4 and figure 5 each should bear the heading "Bursting strength—Pounds per linear inch of pipe;" it being understood of course that the values are those which result from the method used, namely that of taking two tensile specimens from each length of pipe, one from the thin side and one from the thick, multiplying the tensile strength in pounds per square inch by this thickness and choosing in each case the smallest result. The results given are not values recommended for safe loads necessarily, but are primarily for comparison of one pipe with another according to the method of test devised.

Mr. Enger points out that ultimate tensile strengths calculated from bursting tests have been found to be materially lower than ultimate tensile tests strengths determined from tensile tests on small specimens cut from pipe. This was known, and is one of the reasons why we thought it unwise to use the exceedingly small tensile specimen which cuts away some of the material which actually functions in service. Our test specimens were fully representative of all the material in the pipe between inner and outer surface at the place where the specimen was taken, whereas it is thought that the small specimens referred to by Mr. Enger were not. Relative to Mr. Enger's opinion concerning the weight that can be given the bursting pressure in Table 4, it should be kept in mind that these values are the smallest tensile strength of an inch length of pipe and that while we believe this to be fairly representative of each pipe's ability to withstand circumferential tension, the figures are more for the purpose of showing just what relative values the pipe in question gave.

Mr. Enger's comments relative to the use of data on Delavaud pipe taken from a former test are well made. Continuing this series of tests from a start made two years previously was agreed

upon by the parties concerned at the beginning, and had it appeared that the position of Delavaud would have been materially changed, it is thought that a delay could have been arranged for to bring in the newer Delavaud pipe for the tension test as well as for impact and radial compression.

Concerning Mr. Enger's comment on the use of an 18-inch length of pipe for studying variation in thickness and in particular his last sentence thereon we quite agree. We doubt if there ever was an 18-inch portion of a 12- or 16-foot pipe that was constant as Mr. Enger suggests, but it is recognized that Talbot's and Richart's method of using a full length of pipe is better. That, combined with the fact that in this investigation dimensional properties do not carry the weight that was accorded to physical properties, caused us to put it last in importance with variation in weight. This does not mean, of course, that Sand-Cast and Delavaud would change places if we had used full length pipes.

The question of the limited amount of material is one that will never be satisfactorily answered under the existing conditions. Competent engineers from the city of Detroit were satisfied in one way at least; namely, that they wanted as comprehensive a study as could be made with the available appropriation. We believe the investigation of Talbot and Richart was an excellent one and without doubt could be summarized in such a way as to give some idea of relative service merit. It is possible that a larger number of tests might explain the inconsistency in the order of merit between the 6- and 8-inch pipe, but that it would do without doubt, leaves out of the question entirely the fact which Mr. Enger clearly points out, namely, that "there is a considerable difference in the results of the various tests on different lots of pipe from any given manufacturer," and further it ignores the fact that even though the quality were the same the necessary minimum thickness of an 8-inch pipe as compared with a 6-inch to give the same resistance to internal bursting pressure might not be attained.

Mr. Enger says that "an excess of merit in one respect cannot be substituted for a deficiency in another." That is certainly true if by deficiency he means a defect which would place the pipe in the reject class without any further consideration. But this pipe did not fall in the reject class, all of it "met the published specifications under which it is sold" quoting the original article.

As to the fallacy in giving points "which may be added together

to give the measure of service merit," the authors do not believe this system is perfect as yet, but that it is better than the old style way of doing a good job of investigating and then recording it in such a way that no one can tell what conclusions to draw. We submit that if one required a car and laid down the specification that it must be a five-passenger, guaranteed for one year against mechanical and tire defects and have a maximum speed of not less than sixty miles an hour, that most people would choose that car out of two submitted (both of which fulfilled specifications) which would go eighty miles an hour. What is the reason for comparative tests, why do we use the word comparative? If pipe were sold on one specification only, namely, tension, and one kind ran 25,000 pounds per square inch (20,000 being the minimum acceptable) and another 30,000 pounds per square inch, which would the average board of public works take, price being the same? Automatically one pipe takes first place and the other second in the minds of the purchasers, regardless of how fallacious it may be to an engineer. But that at once amounts to giving points. Then if we extend the idea to two requirements, tension and impact, and we agree that the two qualities are of equal importance, and suppose the pipe gave results of 20,000 and 30,000 pounds per square inch respectively as before with impact resistance on a standard specimen of 6 and 9 pounds feet respectively, the requirement being five pounds feet; again and without hesitation the buyer places the 30,000 pounds per square inch pipe first in each requirement and the other second. But placing two pipes in order of first and second is giving numbers again.

One more illustration, suppose the same pipe as above but reverse the impact resistances. Then the 30,000 pound per square inch pipe is first in tension and second in impact; we give two points for first place in tension, and one for second in impact, or a total of three. By the same system of judging the 20,000 pound per square inch tension pipe gets three points. In such simple cases it is obviously not necessary to resort to the point system for one would just say without adding points that the pipe both passes minimum requirements and were equally desirable above that. But if one were to reduce one's thinking process to writing, points would be given whether or no.

So it seems that the fallacy is not in giving points in the way outlined, but error in weighing the relative importance of tension and

impact might give fallacious results. This phase of the comparison was commented on by the authors on page 831.

Concerning Mr. Enger's last paragraph and particularly his last sentence, we should like to amend it by making it read: This in effect is equivalent to saying that any of these pipes will function to a degree that shall satisfy the ordinary uses to which pipe are put, but that progress in all lines of manufacturing is being made, automatically raising standards, and that the vertical Sand-Cast pipe at present does not successfully compete.

F. N. Menefee.[4]

[4] Department of Engineering Research, University of Michigan, Ann Arbor, Michigan.

SOCIETY AFFAIRS

THE ANNUAL CONVENTION

The fiftieth annual convention of the American Water Works Association was held at the Hotel Jefferson, St. Louis, Mo. from June 2 to 6, 1930. The guests began arriving as early as Saturday, May 31, and by Monday over 700 had registered at the Secretary's office on the mezzanine floor of the hotel.

The members assembled in the Gold Room of the Jefferson at 2 p.m. on Monday June 2, for the first meeting of the Plant Management and Operation Division and Superintendents' Round Table Discussion,[1] with James Sheahan, Superintendent of Memphis, Tenn., Water Department, in the chair.

Mr. H. Clay Henning, Assistant Division Engineer, St. Louis Water Division, discussed the Installation and Care of Centrifugal Pumps and Use of Check Valves on Pump Discharge Mains. This was also discussed by William W. Brush, William Luscombe and others.

Topic No. 2, Clearance Between Water Mains and Subsurface Structures and Conditions Requiring Supports to Prevent Load Being Transmitted to Mains, was treated by William W. Brush in a short paper. The question was discussed by Gibson, Doane, Ackerman, Skinker, Morris and others.

Topic No. 4, Inspection of Fire Hydrants and Division of Responsibility Between Fire and Water Departments was led by Charles W. Winkle.

R. L. Dobbin handled Topic No. 5, Frost Protection Coverings for Exposed Water Mains.

No. 6, Water Mains on Bridges and Viaducts, with Special Reference to Use of Relief Valves in Northern Communities, was led by Marcel Pequegnat.

James E. Gibson spoke on the subject of Painting and Maintenance of Elevated Tanks and Standpipes.

No. 8, the Assessment of Water Mains Against Frontage, was discussed by C. D. Brown.

[1] JOURNAL, October, 1930, page 1303.

An informal reception and dance was held in the Gold Room of the Hotel Jefferson on Monday evening.

Tuesday Morning, June 3. The convention was officially opened by President Hinman on Tuesday morning. He spoke of the fact that the first convention, 50 years ago, had been held in St. Louis, and emphasized what the city had done for the Association. Secretary Beekman C. Little read the list of officers elected for the ensuing Association year, as follows: President, George H. Fenkell, Superintendent and General Manager, Board of Water Commissioners, Detroit, Mich.; Treasurer, William W. Brush, Chief Engineer, Department of Water Supply, Gas and Electricity, New York City.

The chair then called upon President-Elect Fenkell, who asked hearty support of all of the members during his coming administration and requested those who had suggestions to make that would improve the association to send them to him. He assured the members that he would give all that was in him to the work of his office during the coming year.

Secretary Little reported the receipts of the year as $65,985.18 and expenditures $58,517.26, leaving a balance of $7,467.92. The Association has never been in a better financial condition. The income for the coming year will be greater owing to the increase in membership. Last year there had been an increase of 314 members and this year, so far, the increase has been 351. The membership of all classes is as follows: Honorary, 12; Active, 2,387; Corporate, 116; Associate, 227; making a total of 2,842.

Two sections have been added for the year; the New England and the Southeastern, making 18 sections in all.

Secretary Little read the report of the Governing Board. The budget for the coming year is $67,432. The following seven honorary members have been elected: John W. Alvord, Chicago; Allen Hazen, New York City; Daniel W. Mead, Madison, Wis.; Dabney N. Maury, Chevy Chase, Md.; Arthur N. Talbot, Urbana, Ill.; Robert Spurr Weston, Boston, Mass.; and X. Henry Goodnough, Boston, Mass. Reference was made in the report of the revision of the constitution by the committee under the chairmanship of R. L. Dobbin. This committee had been active during the year in making changes smoothing out the constitution, so as to make its operation as nearly perfect as possible.

In his report, Treasurer William W. Brush announced that $7,000 had been added to the Association's permanent fund. In a short address he accepted his re-election as Treasurer.

In his address, President Hinman reviewed the history of the Association, showing on the screen portraits of the first twenty of the Presidents. He spoke of the splendid condition of the Association at present, and paid a tribute to the work done by the membership committee, under Arthur E. Gorman.

The chair then called upon R. L. Dobbin, Superintendent, Water Works, Peterborough, Ont., Can., to whom he presented the John M. Diven Memorial Medal, for Mr. Dobbin's work in connection with the formulation of the new constitution. This medal is presented each year to the member who has done the most outstanding work for the Association.

Arthur E. Gorman presented the report of the Membership Committee. He referred to the support given him by the members, 543 active members having been engaged in the intensive campaign to increase the membership, and in following up prospects. Since January 1, 1930, 404 members had been added, and he felt sure the 500 aimed at in the drive would be reached before the end of the convention.

President Hinman showed a portrait on the screen of William Molis, water works superintendent of Muscatine, Iowa, when he joined the association on March 15, 1882, and one of him at the present day. He then asked Mr. Molis to rise and the oldest member in point of service received a hearty welcome by the members present.

Only one paper was read at this session, owing to the lateness of the hour. It was "The Development of Railway Water Supply Practice," by C. R. Knowles, who reviewed the improvements which had taken place in this branch of water supply in the past 50 years and spoke of some of the problems which still exist. The paper was discussed by C. N. Koyl, Engineer, Water Service, Chicago, Milwaukee, St. Paul & Pacific R. R. Co., Chicago, Ill., and R. C. Bardwell, Superintendent Water Supply, C. & O. R. R. Co., Richmond, Va.

Tuesday Afternoon, June 3. The first paper of the Tuesday afternoon session was on "Recent Progress in the Art of Water Treatment,"[2] by Abel Wolman, Wellington Donaldson, and Linn H. Enslow.

John D. Fleming read a paper on "The Purification of Highly Turbid Waters."

The next paper was on "Recent Water Borne Disease Outbreaks and Their Significance," by Abel Wolman and A. E. Gorman.

[2] JOURNAL, September, 1930, page 1161.

"Private Cross Connections and Similar Menaces to Quality of the General Public Supply," was presented by Joel I. Connolly. The first to discuss this paper was William C. Groeniger, Consulting Sanitary Engineer, Columbus, Ohio. He believed that all bypasses into the water system should be eliminated to avoid any possibilities of seepage back into the water supply.

S. B. Morris said that no valve with moving parts could be expected to avoid pollution. He read a Pasadena ordinance giving the water department power to supervise all fresh water piping. He pointed out dangers arising through carelessness or malice of the consumer.

Mr. Connolly said that new devices are the most dangerous. The problem is to prevent future improper devices and to watch the construction of new buildings.

Water Purification Division Dinner

Some two hundred members attended the annual dinner of the Water Purification Division at 7 p.m. on Tuesday at the Statler Hotel. A talented quartet furnished the entertainment—that is, part of it. The most important part, however, was furnished by Toastmaster William J. Orchard. He summoned twenty-four of the prominent members of the Division to the speakers' table, and after ranging them against the wall, staged an old fashioned "spelling bee," taking all of the words from the Manual of Water Works Practice. At each miss, he sounded a huge gong, and finally succeeded in eliminating every contestant in the bee. The affair was thoroughly enjoyed by all, including the unfortunate "victims" of the contest.

At 12.30 the ladies of the convention were entertained by a luncheon and bridge at the Jefferson Hotel. In the evening the ladies—and a number of men—were entertained with opera at the unique open air auditorium of the Municipal Theatre.

Wednesday Morning, June 4. The first paper on Wednesday morning was by William W. Hurlbut, Water Distribution Engineer, Department of Water and Power, Los Angeles, Cal., on "Steel Trunk Lines with Bell and Spigot Joints."[3] In the absence of Mr. Hurlbut the paper was read by Mr. Morris.

The first discussion of this paper, by George W. Pracy, Superin-

[3] JOURNAL, September, 1930, page 1178.

tendent of City Distribution Division, San Francisco Water Department, was also read by Mr. Morris in Mr. Pracy's absence.

F. M. Randlett, of the Robert W. Hunt Company, of San Francisco, Cal., in discussing the paper, remarked that what had been said does not show that bell and spigot joints would be economical under all conditions. The annual as well as the first cost should enter into the calculations. Rivetted pipe has been used for many years successfully.

Mr. Pracy in his discussion pointed out that bell and spigot joints possess a flexibility not found in other types.

Mr. Brush spoke of New York City's experience with steel pipe of 30-inches and over.

J. W. Ledoux, Consulting Engineer, of Philadelphia, had used cement joints in a steel pipe line.

George H. Fenkell had used both Lock Bar and rivetted pipe.

Alfred O. Doane told of experiments by the Metropolitan District of Boston in endeavoring to prevent electrolysis.

Mr. Gibson cited an instance in western Pennsylvania where mains laid on the side of a hill, with a slight movement, had used Dresser joints successfully.

Mr. Morris said his method of joints differed in that he used two parts of cement and one of sand.

The next paper was advanced from the Thursday afternoon session. It was by Loran D. Gayton, City Engineer, Chicago, Ill., on "The Advance Planning and Operating Results of Pumping Facilities at Chicago." This paper described the preliminary work in planning improvements in the pumping facilities of Chicago, and the excellent results which followed.

"Two Interesting Failures of Welds on Small Patches in Large Steel Pipe," were described and illustrated by Mr. Brush in this short paper. It was discussed by George H. Fenkell, G. Gale Dixon and Chester A. Truman.

The next paper, by Burt B. Hodgman, Consulting Engineer, National Water Main Cleaning Company, New York City, on "Cast Iron Pipe After 260 Years' Service in Gardens of Versailles, France," was illustrated by lantern slides. It described the pipe line and pumping station at Versailles, built 260 years ago, by order of King Louis XIV of France, and still in use in that city.

The final paper of the session was entitled "Disaster Preparedness Plans for Water Works."[4] in the absence of Mr. Pracy it was read

[4] Journal, September, 1930, page 1200.

by Mr. Morris. Mr. Pracy treated the subject from the standpoint of earthquakes.

Mr. Morris discussed the paper also from the standpoint of earthquake disasters.

John H. O'Neill, Sanitary Engineer, Louisiana State Board of Health, New Orleans, La., on the other hand, treated the subject from the point of view of great floods. He said that one difference was that, while with the earthquake there was no warning, the great rivers gave, as a rule, ample notice of their intention to overflow their banks. Plants, he said, should wherever possible, be located above the flood area. A second source of power supply should always be provided. All water seepage and waste water should be quickly removed to avoid pollution.

The discussion by E. L. Filby was read by Arthur Gorman. Mr. Filby treated the subject in a broader way. He said that the superintendent of the water works should always be prepared, whether through tornado or hurricane, flood or earthquake. He should plan ahead as to what should be done in all such cases, so as to be prepared when the emergency did arise.

Wednesday Afternoon, June 4. There were no sessions on Wednesday afternoon and the members took advantage of this fact to visit the water works, especially the new Howard Bend plant. This they were enabled to do through the courtesy of the St. Louis Water Department which ran a continual service of buses to the Howard Bend plant and autos to others.

A smoker was given in the evening for the men, and the ladies were invited to witness the entertainment provided from the galleries of the Gold Room of the Jefferson Hotel.

Thursday Morning, June 5. The first paper was on the subject of "Hydraulics of Deep Wells,"[5] by the late L. R. Balch, formerly of Mead & Seastone, Consulting Engineers, Madison, Wis., and was presented by Daniel W. Mead, Madison, Wis.

The next paper by C. N. Ward, Mead & Seastone, Consulting Engineers, Madison, Wis., was on the subject "Air Lift Pumps vs. Centrifugal and other Deep Well Pumps." Those discussing this paper were A. P. Pigman, Mechanical Engineer, American Water Works & Electric Company, New York City, Thomas H. Allen, Memphis, Tenn., and L. A. Smith, Superintendent of Water Works, Madison, Wis.

[5] JOURNAL, June, 1930, page 755.

At this point the Chair announced the personnel of the Committee on Resolutions as follows: Messrs. Cramer, Gibson, Morse, Howson and Dobbin.

A telegram was received extending the greetings of Mrs. John M. Diven to the convention.

An announcement was made of the death of Dow R. Gwinn, Ex-President of the Association, at Terre Haute, Ind.

The next two papers and discussions on them were arranged especially with a view of interesting the members of the new Finance and Accounting Division, formed at last year's convention. Many of the members of this Division were present at this session.

The first of these accounting papers was by H. Gordon Calder, Assistant Comptroller, Federal Water Service Corporation, New York City, and was on the subject of "Importance of Proper Financing and Accounting in Water Works Practice." It was read by a substitute, as Mr. Calder was unable to be present. The paper was discussed by C. Van den Berg, President of the Alabama Water Service Company, Birmingham, Ala., and F. W. Schulz, Comptroller, Community Water Service Company, New York City.

The final paper of the session was on "Problems of Water Utility Finance," by A. P. Michaels, General Manager, Orlando, Fla., Utilities Commission. He pointed out that the successful utility must arrange its rates so as to take care of extensions and improvements. Whether such financing is successful must depend upon the officers of the utility. If net income is insufficient, the ideal plan is to follow the policy of improvements to provide a greater return. Extensions into new territory should be based upon how much of the expected returns can be foreseen. A budget is an important step in the right direction. Extravagant items of expenditure should be excluded from the budget.

A discussion by E. W. Agar, Superintendent of Water Department, Valparaiso, Ind., was presented, but not read.

Thursday Afternoon, June 5. The first paper on Thursday afternoon of the main session was on "Wastefulness and its Correction in Operation of Pumping Stations," by T. R. Hughes, Mechanical Engineer, American Water Works & Electric Company, New York City. Discussion on this paper by A. D. Couch, Mechanical Engineer, Community Water Service Company, New York City, was read by a substitute in Mr. Couch's absence.

The next paper by R. D. Hall, Manager Water Works Sales,

Worthington Pump and Machinery Corporation, New York City, was on "Diesel Engines as Applied to Water Works Service."

Dewey M. Radcliffe, Associate Engineer, U. S. Engineers Office, Washington, D. C., read a paper on "Obtaining Water Level Readings by Automatic Telephone."

Plant Management Division, Business Meeting

At the close of the session the business meeting of the Plant Management and Operation Division was held. The officers elected were: President, Stephen H. Taylor, Superintendent Water Department, New Bedford, Mass.; Vice President, Ray Crozier, Superintendent of Water Works, Peoria, Ill.; Secretary, A. V. Ruggles, Assistant to the Secretary, American Water Works Association, New York City; Trustees, R. B. Simms, Superintendent Water Works, Spartansburg, S. C.; George W. Pracy, Superintendent Spring Valley Water Company, San Francisco, Cal.

Finance and Accounting Division

A special meeting of the Finance and Accounting Division was held Thursday afternoon at which time the assembled group went into session as a committee of the whole to discuss a permanent program for the Division, as suggested by Vice-Chairman Smith. After the opinions of the group seemed to be in agreement, a subcommittee on recommendations was appointed, with instructions to report to the regular meeting Friday morning, June 6, with definite recommendations for action as to the subject discussed: C. J. Alfke, F. W. Schultz, A. P. Michaels, D. C. Grobbel.

Their report presented at the Friday meeting contained the following recommendations:

That the objective of the Division, the scope of the Division, and the relationship of the Division to the committee on water works practice, as suggested by the Vice-Chairman, be adopted.

That the chairman of the Division elected at this convention, be authorized to appoint chairmen of the sections, and that each chairmen so appointed, be authorized to appoint his own committee.

That at least one session of the Division be assigned to round table discussion and that the round table be held on the second day of the annual convention so as not to interfere with the round table of the Superintendents.

That the business meeting of the Division scheduled for Friday

afternoon, be changed to Friday morning to accommodate members of the Division desiring to leave the city at noon, and that at this business meeting of the Division, the officers for the Division be elected.

The above recommendations were adopted by the Division at its regular meeting Friday morning.

In regular order of business the following papers were read and discussed:

"Mechanical Accounting for Water Utilities"by P. H. Hutchinson, Public Service Division, Burroughs Adding Machine Co., New York City.

Mr. Hutchinson was unable to attend the convention. His paper was read by E. C. Munro, Austin, Texas. Discussion of this paper was lead by L. M. Anderson, Comptroller, Department of Water and Power, Los Angeles, Calif.

Mr. F. W. Schulz lead a lively discussion on "Standard Classification of Accounts for Water Works."

Mr. C. J. Alfke, Comptroller, Hanckensack Water Company, Weehawken, New Jersey, presented a paper dealing with "Collection of Bills for Water Service."

The newly elected officers are: Chairman, Hal F. Smith, Head Water Consumers Accounts Clerk, Department of Water Supply, Detroit, Michigan; Vice-Chairman, A. P. Michaels, General Manager, Orlando Utilities Commission, Orlando, Florida; Secretary, G. D. Kennedy, Civil Engineer, Department of Water Supply, Pontiac, Michigan; Directors, H. Gordon Calder, Assistant Comptroller, Federal Water Service Corporation, New York City; A. M. Bowman, Supt. of Public Utilities, Elmira, Ontario, Canada.

Dinner Dance, Thursday Evening

At 7.30 p.m. on Thursday evening the entire convention assembled for the Dinner Dance. This was held in the Gold Room, and the gathering was a large one. At the conclusion of the dinner, tables were cleared away and the members and guests spent an enjoyable evening.

Friday Morning, June 6. President Hinman opened the Friday morning session. He said that during the year of his incumbency he had traveled over the country in the interests of the association and had enjoyed it. He had found interest in the association and its aims and purposes general and hearty and he believed that its devel-

opment is going steadily forward. This progress was largely in the hands of the members.

He referred to the value of the abstracts and believed that many were not getting the benefit they should from this feature of the association's work. He thanked the Association for having elected him to the position of President. It had been a great privilege to serve the Association and he wanted all to know how much he had realized this. He appreciated also the very fine coöperation he had received from the Secretary's office.

Mr. Fenkell, he said, was entering upon his duties at a time when the numerical strength of the Association is rising rapidly, owing to the splendid work of the membership committee under Arthur Gorman. He then called President-Elect Fenkell to the chair.

Mr. Fenkell said he fully appreciated the honor conferred upon him by the Association, and intended to do all in his power in the interests of the Association. He spoke of the lack of general discussion at this convention, but said with the great number of papers and the prepared discussions, very little time was left for much talk by members from the floor.

The first paper of the session was by J. S. Whitener, Assistant Professor of Sanitary Engineering, North Carolina State College of Agriculture and Engineering, Raleigh, N. C., on "Training Operating Personnel for Small Purification Works."

The paper was discussed by Abel Wolman, Chief Engineer, Maryland State Department of Health, Baltimore, Md.; E. S. Tisdale, Director, W. Va. State Department of Health, Charleston; and Thomas R. Lathrop, Assistant Engineer, Ohio State Department of Health, Columbus, Ohio.

The next paper was on "Operating Experiences with a New Automatic Residual Chlorine Recorder and Controller,"[6] by J. Westford Cutler, Experimental Engineer, Wallace & Tiernan Company, Inc., Newark, N. J., and Frank W. Green, Superintendent of Filtration and Pumping, Passaic Consolidated Water Company, Little Falls, N. J.

The two papers which followed described the means employed in the development of the programs of improvement of distribution systems in St. Louis by Thomas J. Skinker, Division Engineer, and Meyer Serkes, Civil Engineer, Distribution Section, St. Louis, and

[6] JOURNAL, June, 1930, page 755.

was read by Mr. Serkes; and in Detroit by F. H. Stephenson, Engineer of Water System, Detroit, and was read by Arthur B. Morrill.

The discussion on this paper was by Louis F. Ayres, of Ayres, Lewis, Norris & May, Engineers, Ann Arbor, Mich., and consisted of a comparison of the methods and of conditions which prevailed in the two cities, causing such a diverse result in the program of improvement. J. B. Eddy, of Chicago, and V. Bernard Siems, of New York City, discussed the paper further.

Friday Afternoon, June 6. S. B. Morris, Chief Engineer, Water Department, Pasadena, Cal., presided. The committee on resolutions recommended that the thanks of the Association be extended to the cities of St. Louis, to the Water Department, to Commissioner Day and Messrs. Skinker, Fleming and others of the staff who had so well contributed to the pleasure of the members; to the press of the city of St. Louis, and to the St. Louis Tourists' Bureau. On motion, these resolutions were adopted.

The first paper was by N. T. Veatch, Jr., Consulting Engineer, Kansas City, Mo. His subject was "Water Requirements of Cities in Arid and Semi-Arid Climates," and he spoke specifically on the effect of climate on requirements of representative western and southwestern cities having relatively dry or hot and dry summers, with special reference to irrigation needs.

This paper was discussed by Richard Bennett, Superintendent Water Department, Tucson, Ariz., and by Chairman Morris.

The second paper was by S. F. Newkirk, Jr., Superintendent and Engineer, Elizabethtown Water Company, Consolidated, Elizabeth, N. J., on the subject "Water Supply for Airports."[7]

The paper was discussed by Herman Rosenstreter, Engineer of Water Supply, Newark, N. J., who referred to the Newark test. Another discussion was by Clarence Goldsmith, Assistant Chief Engineer, National Board of Fire Underwriters, Chicago, Ill.

The next paper was presented in excerpt form by R. W. Reynolds, Superintendent, West Palm Beach Water Company, West Palm Beach, Fla. Its subject was "Investigation of Service Pipes of Various Materials." It dealt principally with friction loss tests with particular reference to the carrying capacity of copper tubing in comparison with other classes of pipe. It was illustrated by slides, diagrams and tables.

[7] JOURNAL, September, 1930, page 1189.

Conference of Committee on Boiler Feed Water Studies

This conference was held on Tuesday afternoon, June 3. The following papers were presented.

Recent Developments in Boiler Feed Water Treatment. Sheppard T. Powell.

Some Corrosion Problems. F. B. Porter, President, Southwestern Laboratories, Fort Worth, Texas.

Boiler Feed Water Problems and Their Solution in Great Britain. Dr. A. M. Chapman, Sheffield, England.

Experiences with the Embrittlement of Boiler Steel in Germany. Dr. Splittberger, Bautzen, Germany.

Advantages of Purification of Boiler Feed Water for Evaporators.[8] Professor Hugo A. Haupt, Bautzen, Germany.

Water Purification Division

These sessions were presided over by Frank E. Hale, Chairman, Director of Laboratories, Department of Water Supply, Mt. Prospect Laboratory, Brooklyn, N. Y. The papers presented were as follows:

Wednesday Morning, June 4. Successful Application of Superchlorination and Dechlorination for Medicinal Taste to a Well Supply, Jamaica, N. Y. Frank E. Hale, Director of Laboratories, Department of Water Supply, Mt. Prospect Laboratory, Brooklyn, N. Y. Discussion led by Alan M. E. Johnstone, Manager, New York District, Wallace & Tiernan Company, Inc., New York, N. Y.; George R. Spalding, Assistant Superintendent, Filtration and Sanitation, Hackensack Water Company, New Milford, N. J.

Progress in Superchlorination Treatment for Taste Prevention at Toronto together with some studies on Chlorine Absorption. N. J. Howard, Director of Water Purification, Island Filtration Laboratories, Toronto, Ont.. Discussion led by Linn H. Enslow, Research Engineer, The Chlorine Institute, Inc., New York; Harry E. Jordan, Sanitary Engineer, Indianapolis Water Company, Indianapolis, Ind.; Louis B. Harrison, Superintendent Filtration, Department of Public Utilities, Bay City, Mich.

Chemical and Mechanical Utilization of Activated Carbon in Water Purification.[9] A. S. Behrman, Chemical Director and H. B. Crane, Principal Assistant Engineer, International Filter Co., Chicago, Ill. Discussion led by Paul Hansen, Consulting Engineer,

[8] JOURNAL, October, 1930, page 1345.

[9] JOURNAL, November, 1930, page 1399.

Pearse, Greeley and Hansen, Chicago, Ill.; R. A. Hoot, Civil Engineer, Department of Water Supply, Pontiac, Mich.

The Use of Activated Carbon for the Removal of Taste and Odor from Water.[10] George D. Norcom, Sanitary Engineer, Federal Water Service Corporation, New York, N. Y. Discussion led by Robert Spurr Weston, Consulting Sanitary Engineer, Boston, Mass.

Further Observations on the Use of Activated Carbon in Removing Objectionable Tastes and Odors from Water.[11] John T. Baylis, Filtration Engineer, Bureau of Engineering, Chicago, Ill. Discussion led by Charles P. Hoover, Chemist in Charge, Water Softening and Purification Works, Columbus, Ohio; W. A. Helbig, Chemist, Darco Sales Corporation, New York, N. Y.

Thursday Morning, June 5. Some Neglected Dangers to Water Quality. Jack J. Hinman, Jr., Associate Professor of Sanitation, University of Iowa, Iowa City, Iowa. Discussion led by Edward Bartow, University of Iowa, Iowa City, Iowa.

Unusual Color Removal Plant for part of the Los Angeles Water Supply. Carl Wilson, Laboratory Director, Department of Water & Power, Los Angeles, Calif. Discussion led by Linn H. Enslow, Research Engineer, The Chlorine Institute, New York, N. Y.; J. S. Whitener, Assistant Professor of Sanitary Engineering, North Carolina State College, Raleigh, N. C.; L. L. Hedgespeth, Sanitary Engineer, Pennsylvania Salt Manufacturing Company, Widener Building, Philadelphia, Pa.

The Trial Filtration Plant, Ottawa, Canada.[12] George G. Nasmith, Consulting Civil Engineer, Gore, Nasmith & Storrie, Toronto, Ont. Discussion led by W. E. MacDonald, City Water Works Engineer, Ottawa, Canada.

Prechlorination in Relation to Filter Plant Efficiency. H. W. Streeter, Sanitary Engineer, and C. T. Wright, Technical Assistant, U. S. Public Health Service, Cincinnati, O. Discussion led by Linn H. Enslow, Research Engineer, The Chlorine Institute, New York, N. Y.; Ralph A. Stevenson, Superintendent of Filtration, Sacramento, Calif.

Observations on Filter Sand Shrinkage. W. M. Wallace, Superintendent of Filtration, Roberts Hulbert, Senior Chemist, and Douglas

[10] Journal, November, 1930, page 1414.
[11] Journal, November, 1930, page 1438.
[12] Journal, August, 1913, page 1017.

Feben, Junior Chemist, Department of Water Supply, Detroit, Mich. Discussion led by Frank W. Herring, Editorial Assistant, Engineering News-Record, Chicago, Ill.; Charles R. Cox, Assistant Sanitarian, Department of Health, Albany, N. Y.; Lyle J. Jenne, Sanitary Engineer, Bureau of Water, Department of Public Works, Philadelphia, Pa.

Manipulation of pH at Springfield, Ill., Water Purification Plant. Charles H. Spaulding, Chemist and Superintendent Water Purification Department of Water, Light & Power, Springfield, Ill. Discussion led by John D. Fleming, Chief Chemical Engineer, Howard Bend Station, Water Division, St. Louis, Mo.; Charles P. Hoover, Chemist in Charge, Water Softening & Purification Works, Columbus, Ohio.

Thursday Afternoon, June 5. Efficient Water Works Operation and the Purification Laboratory. Martin E. Flentje, Superintendent of Purification, Community Water Service Co., Harrisburg, Pa., and P. S. Wilson, Superintendent of Operation, Community Water Service Co., New York, N. Y. Discussion led by L. T. Reinicker, Operating Manager, National Water Works Corporation, Reading, Pa.; William U. Gallaher, General Chemical Co., Chicago, Ill.

Elimination of Taste in the Water Supply of Lancaster, Pa. Edward D. Ruth, Lancaster, Pa. Discussion led by Howard J. Pardee, The Pardee Engineering Co., Long Island City, N. Y.

Preammoniation of the Filtered Water Supply of Cleveland, Ohio. J. W. Ellms, Engineer, Water Purification & Sewage Disposal, Department of Public Utilities, Cleveland, O. Discussion led by Linn H. Enslow, Research Engineer, The Chlorine Institute, New York, N. Y.; Howard J. Pardee, The Pardee Engineering Co., Long Island City, N. Y.; Louis B. Harrison, Superintendent of Filtration, Department of Public Utilities, Bay City, Mich.

Efficiency of Chlorination at Chicago. H. H. Gerstein, Sanitary Engineer, Division of Water Safety Control, Bureau of Engineering, Chicago, Ill. Discussion led by Arthur E. Gorman, Wallace & Tiernan Company, Inc., Newark, N. J.

The Elimination of Coli-Aerogenes Contamination, due to Pump Packing, from a High Pressure Centrifugal Pump. Arthur F. Mellen, Filtration Engineer, Columbia Heights Filtration Plant, Minneapolis, Minn. Discussion led by Fred. O. Tonney, Director of Laboratories & Research, Department of Health, Chicago, Ill.

A Demonstration of Direct Counting of Coli-Aerogenes Organisms

in Cyanide Citrate Agar. Ralph E. Noble, Senior Bacteriologist, Chicago Department of Health, City Hall, Chicago, Ill.; with a brief discussion of the improved and simplified technic by Fred. O. Tonney, Director of Laboratories & Research, Department of Health, Chicago, Ill.

ABSTRACTS OF WATER WORKS LITERATURE[1]

FRANK HANNAN

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

The Biology of the Bog Lakes as Examined on the Bog Dams of the Iser Mountains. FRITZ GESSNER. Arch. Hydrobiol., 20: 1–64, 1929. From Chem. Abst., 23: 3243, July 10, 1929. Study of physical, chemical, and biological properties of 2 true bog lakes formed by construction of dams. These lakes have exceptionally high acidity (pH 5.1–5.7). The pH decreased from surface toward bottom, indicating that acidity originates at bottom, degree of acidity depending on location of lake, the quantity of water flowing through, and the age of the lake. Assumed that pH increases with increasing age.—*R. E. Thompson.*

The Conditions Under Which the Antibacterial and Antitoxic Power of Bile is Manifested. II. The Growth of Bacillus Coli in the Presence of Bile or Bile Salts. A. CLEMENTI and A. CASTELLI. Arch. sci. biol. (Italy), 13: 221–34, 1929. From Chem. Abst., 23: 3248, July 10, 1929. Object was to prove that inhibiting action of bile or bile salts on growth of bacteria is due to formation of insoluble bile acids which flocculate and carry down with precipitate some of bacteria. Results of bacterial count showed that in presence of bile or bile salts there was marked inhibition in growth of *B. coli* if reaction of broth became acid owing to fermentation of dextrose, or is rendered acid artificially by addition of lactic acid, but there was no inhibition if reaction remained alkaline. Results explain contradictory statements found in literature.—*R. E. Thompson.*

Growth and Operation of Water Works. H. EIGENBRODT. Bauing. 1928, 609–14, 627–31, 643–7, 666–70, 721–5, 734–9; Wasser u. Abwasser, 25: 133. From Chem. Abst., 23: 3285, July 10, 1929. Water consumption in Germany has constantly increased since introduction of modern water works.—*R. E. Thompson.*

Katadyn, a New Method of Water Sterilization. A. THIEME. Chem.-Ztg., 53: 285–7, 1929; cf. C. A., 23: 1452, 1702. From Chem. Abst., 23: 3286, July

[1] Vacancies on the abstracting staff occur from time to time. Member desirous of coöperating in this work are earnestly requested to communicate with the chief abstractor, Frank Hannan, 285 Willow Avenue, Toronto 8, Ontario, Canada.

10, 1929. Study of KRAUSE patents, Brit. 293, 385 and Fr. 643, 610, which claim that silver, cadmium, palladium, and copper, as well as other metals, possess sterilizing properties for liquids placed in contact with them. Treatment of water by exposure to these metals, particularly silver, is reviewed. Containers or flasks are divided into many compartments so as to give large contact area. Treatment may be preceded by filtration, metals being used in filter itself as aid to sterilization. Usually several hours standing is necessary to destroy all bacteria.—*R. E. Thompson.*

Differentiation of Boiled and Raw Water by Means of Hydrogen-Ion Concentration. N. KRASOVSKA-KOLOSAVA. Zentr. ges. Hyg., **18**: 195, 1928; Wasser u. Abwasser, **25**: 141. From Chem. Abst., **23**: 3286, July 10, 1929. Author was able to differentiate between raw and boiled water in 90 per cent of samples examined by determining the pH. There is a pH difference of approximately 0.5. Raw ground water had pH of 6.75, while boiled was 7.2. Similarly, raw brook water was 6.62, and boiled, 7.08.—*R. E. Thompson.*

Method of Filtration According to Puech-Chabal. K. MILOS and G. KABRHELA. Zentr. ges. Hyg., **18**: 324, 1928; Wasser u. Abwasser, **25**: 145. From Chem. Abst., **23**: 3286, July 10, 1929. System consists of repeated sand filtrations, through 3 layers of sand. Diameter of sand grains is 1 to 3 mm. In supplies containing considerable iron, addition of milk of lime previous to filtration proved desirable. Method is very efficacious for removal of *B. coli.* —*R. E. Thompson.*

Corrosion in Steam Heating Systems. F. N. SPELLER. Plumbers Trade J., **86**: 701–4, 752, 1929. From Chem. Abst., **23**: 3527, July 20, 1929. Study of causes of deterioration of piping and how to treat boiler water to guard against corrosion—*R. E. Thompson.*

Accelerated Volumetric Method for Determination of Hardness of Water. I. F. ILCHENKO. Ukrainskii Khem. Zhur., **2**: Tech. Pt., 124–6, 1929. From Chem. Abst., **23**: 3286, July 10, 1929. Permanent hardness when determined by PFEIFER-WARTHA volumetric method was higher than when determined by gravimetric method, due to precipitation of iron and aluminum salts by the alkaline mixture of sodium hydroxide and sodium carbonate. Magnitude of correction is measured as follows: 500 cc. of sample is acidified with nitric acid and treated at 60–70° in presence of ammonium chloride with slight excess of ammonium hydroxide. Precipitate is washed with hot water, dissolved in known amount of hydrochloric acid and diluted to 500 cc. A 100-cc. portion titrated with the sodium hydroxide sodium carbonate mixture using methyl orange as indicator, and the correction calculated from result.—*R. E. Thompson.*

Water from Angoulême, the Cause of Pollution and Effect on Typhoid Morbidity. A. L. CAPDEVILLE. Zentr. ges. Hyg., **18**: 778, 1928; Wasser u. Abwasser **25**: 226. From Chem. Abst., **23**: 3287, July 10, 1929. Unsatisfactory sewage disposal together with unfavorable geological situation caused typhoid

epidemic. Chlorine or "javel" sterilization of drinking water is strongly recommended.—*R. E. Thompson.*

The Pulfrich Stage Photometer as a Turbidity-Measuring Instrument. STEFAN GÄRTNFR. Kolloid-Z., 48: 10–5, 1929. From Chem. Abst., 23: 3378, July 20, 1929. Directions given for use of PULFRICH stage photometer with slight changes in glass receptacles for measurement of turbidity. If extinction coefficent of turbid solution is directly proportional to concentration, then concentration may be exactly evaluated from extinction coefficient by this method; otherwise, it cannot.—*R. E. Thompson.*

Priming and Foaming.—Causes and Controlling Factors. A. L. S. RUDDER. Power House, 23: No. 5, 34, 50, 1929. From Chem. Abst., 23: 3527, July 20, 1929. Causes and prevention of discharges of water with steam are discussed. —*R. E. Thompson.*

A Comparative Study of Different Types of Thermal Stratification in Lakes and Their Influence on the Formation of Marl. E. M. KINDLE. J. Geol., 37: 150–7, 1929. From Chem. Abst., 23: 3422, July 20, 1929. Relatively low temperature of upper zone in Great Lakes and in high mountain lakes (above 5000 feet in southern Canada) prevents development of thin zone of warm water nearly saturated with calcium carbonate, which is essential to marl deposition.—*R. E. Thompson.*

Corrosion of Centrifugal Pumps. R. W. MÜLLER. Korrosion u. Metallschutz, 5: 59–61, 1929. From Chem. Abst., 23: 3430, July 20, 1929. Corrosion of rotors and casings of centrifugal pumps occurs mostly in portions of pumps operating below atmospheric pressure. Corrosion is attributed to liberation of oxygen at metal surfaces. In series pumping systems practically all corrosion occurs in low-pressure stage.—*R. E. Thompson.*

The Attack of Metallic Pipes by Direct and by Alternating Currents. W. BECK. Z. angew. Chem., 41: 1361–7, 1928. From Chem. Abst., 23: 3430, July 20, 1929. Discussion showing theoretical and practical aspects of corrosion by stray currents in alternating and direct current circuits. Alternating current circuits are more dangerous to buried pipe than direct current because of the 3 possible ways in which currents are caused to flow in pipe within reach of stray currents: contact, induction, and influence.—*R. E. Thompson.*

$700,000 Water Works System for Monroe, Louisiana. M. P. HATCHER. Mfrs. Rec., 15: 12, 63–4, 1929. From Chem. Abst., 23: 3524, July 20, 1929. Improvement program provides for 6-m.g.d. filtration plant, 28.5-m.g.d. pumping plant, and 500,000-gallon storage tank.—*R. E. Thompson.*

Regarding the Ferroxyl Indicator. W. VAN WÜLLEN-SCHOLTEN. Korrosion u. Metallschutz, 5: 62–4, 1929. From Chem. Abst., 23: 3430, July 20, 1929. Ferroxyl indicator in studying bare metal gives erroneous results when made up in agar-agar because of fact that it does not show differential aëration

effects. It is also stated that concentrations of potassium ferricyanide and phenolphthalein are too high and that metal is immersed in unnatural electrolyte. Author finds that concentrations of 0.004 per cent phenolphthalein and 0.008 per cent potassium ferricyanide in molal solution of sodium chloride do not appreciably change properties of electrolyte and give results which are not in error.—*R. E. Thompson.*

Practical Methods of Oxy-Acetylene Welding. L. A. Cowles. Power Plant Eg., **33**: 482–3, 530–1, 1929. From Chem. Abst., **23**: 3431, July 20, 1929. General article. Special suggestions made for steel and wrought iron.—*R. E. Thompson.*

The Determination of the Degree of Turbidity of Water. H. Ilzhöfer. Arch. Hyg., **101**: 1–4, 1929. From Chem. Abst., **23**: 3525, July 20, 1929. Photometric method described, giving results which agree with those obtained by use of apparatus of Olszewski and Rosenmüller.—*R. E. Thompson.*

The Hydrogen-Ion Concentration of Bloomington Water, Normal Water, and of Bloomington-Normal Sewage During the Present School Year. H. W. Adams and D. Tarvin. Trans. Illinois Acad. Sci., **21**: 219–21, 1928. From Chem. Abst., **23**: 3525, July 20, 1929. H-ion concentration data given. There seems to be correlation between pH value and season of year.—*R. E. Thompson.*

Investigation on Oxygen in Japanese Lakes. August Thienemann. Arch. Hydrobiol., **19**: 295–8, 1928. From Chem. Abst., **23**: 3525, July 20, 1929. Survey of studies of S. Yoshimura in Geograph. Rev. of Japan **3**: 1117–51, in which classification of Japanese lakes in relation to oxygen content is given.—*R. E. Thompson.*

Water Purification and Handling. E. Link. Z. Ver. deut. Ing., **73**: 553–6, 1929. From Chem. Abst., **23**: 3525, July 20, 1929. Water utilization per capita per day in most German cities is approximately 100 liters. Self-purification in settling basins occurs by mechanical settling out of suspended matters, gradual decimation of bacteria, and chemical transformation of proteinaceous matter to nitrates. Rapid type filters are endorsed. Precipitation of colloidal matter with aluminum salts is best accomplished at isoelectric point. The pH value for optimal precipitation should be below 7. Dosage of 0.1 to 0.3 gram chlorine per cubic meter is recommended. Iron and manganese should be reduced to below 0.1 p.p.m.—*R. E. Thompson.*

Purification of Water Containing Humus by Slow Sand Filtration. C. P. Mom. and K. Holwerda. Mededeel. Dienst Volksgezondheid Nederland. Indië, **17**: 561–8, 1928. From Chem. Abst., **23**: 3525, July 20, 1929. The water examined, which contained iron and humic acids, could not be purified in practical manner by slow sand filtration using ferruginous river sand as filtering medium. Clear filtrate was obtained, but filter was obstructed in from 2 to 4 days. Cause of obstruction was principally in filtering film, which ap-

peared to consist mainly of a precipitate of iron-humic acid compounds. No indication was obtained that organisms present in film caused deposition of the precipitate.—*R. E. Thompson.*

Electroosmotic Water Purifying Plant. J. Becker. Eng. Progress (Berlin), 10: 92–4, 1929. From Chem. Abst., 23: 3525, July 20, 1929. Process provides for removal of salts dissolved in water by means of electrolysis, metal ions separating out at cathode and acid ions at anode. Deposits are free to react with electrolyte at both electrodes. Apparatus consists of ten 3-cell systems of type described arranged together like filter press.—*R. E. Thompson.*

The Effect of Potassium Permanganate in Eliminating Iron from Drinking Water. C. P. Mom and O. H. van der Hout. Mededeel. Dienst Volksgezondheid Nederland.-Indië, 17: 550–60, 1928. From Chem. Abst., 23: 3526, July 20, 1929. Ferrous bicarbonate occurring in subsoil water is not completely oxidized by aëration. Use of contact substance such as ferric hydroxide or manganese dioxide is necessary. During this process, adsorption of ferrous hydroxide and oxygen takes place. Potassium permanganate in amount equivalent to ferrous iron to be oxidized can completely oxidize latter and coagulate the ferric hydroxide produced. Chlorine and hydrogen peroxide do not exert this effect.—*R. E. Thompson.*

Comparative Determination of the Actual Reaction of Moor Waters. II. Employment of the Quinhydrone Method. I. A. Smorodintzev and A. N. Adova. Arch. Hydrobiol., 19: 323–30, 1928. From Chem. Abst., 23: 3526, July 20, 1929. In acid moor waters both the quinhydrone and bufferless indicator methods gave good results, while in alkaline waters of moors of Segge type the deviations from values obtained with H-electrode were often considerable. Of the indicators used, *p*-nitrophenol, 1,2- and 1,4-dinitrophenol gave satisfactory results, while *m*-nitrophenol did not. No larvae of Anopheles were found in waters with pH of below 5.—*R. E. Thompson.*

The Actual Reaction of the Heath-Moor "Seefelder" Near Reinerz and the Significance of the Hydrogen-Ion Concentration for the Individuality of the Moor Fauna. O. Harnisch. Arch. Hydrobiol., 19: 299–300, 1928. From Chem. Abst., 23: 3526, July 20, 1929. After careful investigations, which show that water of the moor has pH value of 3.8 to 4.0, author withdraws attack against S. N. Skadowsky's theory that high acidity of moor water is responsible for scarceness of animal life in heath moors.—*R. E. Thompson.*

The Cost of Softening Water by the Base Exchange Process. H. G. Cathcart. Domestic Eng., 49: 4, 70–4, 1929. From Chem. Abst., 23: 3526, July 20, 1929.—*R. E. Thompson.*

Rational Selection of a Feed-Water Treatment. C. E. Joos. Paper Trade J., 88: 15, 36–44, 1929. From Chem. Abst., 23: 3527, July 20, 1929. Discussion of following factors in connection with use of softened water in boilers, particularly when high pressures are used: degree of residual hardness, corrosive-

ness of the water, reduction in total dissolved solids and suspended matter, protection against embrittlement of boiler metal, cost of treatment including blowdown. Importance of use of phosphate treatment to keep down caustic alkalinity at high pressures is explained.—*R. E. Thompson.*

Purification of Swimming Pool Water. G. C. Dunham. Military Surgeon, **64**: 361-73, 1929. From Chem. Abst., **23**: 3529, July 20, 1929. Study was made of chlorination of swimming pool at Carlisle Barracks. Chlorine enters pool through pipe in wall at deep end at mid-depth and is diffused by bathers. With intermittent chlorination it was found that as number of bathers (cumulative) increased the excess chlorine content decreased to zero and presumptive tests for *B. coli* changed from negative to positive. With continuous chlorination—excess chlorine always being present—presumptive tests for *B. coli* were always negative.—*R. E. Thompson.*

Town Water Supply in India. J. W. Madeley. Munic. Eng. Sanit. Record., **82**: 535, 1928: cf. C. A., **23**: 1193. From Chem. Abst., **23**: 3762, August 10, 1929. Most large Indian towns are still supplied with water from shallow wells and tanks. Slow sand filtration is most usual. Water must be conserved.—*R. E. Thompson.*

The Softening of Magnesium Water by the Lime-Soda Process. S. R. Trotman. Dyer, Calico Printer, **61**: 192-3, 268-9, 1929. From Chem. Abst., **23**: 3763, August 10, 1929. Various factors affecting precipitation of magnesia are considered, and a method is described for determining optimum amounts of lime and soda to use in softening.—*R. E. Thompson.*

Apparatus for Dissolving and Feeding Calcium Hydroxide into Iron Pipes to Check Corrosion by Water, etc. Christian Bücher. U. S. 1,716,205, June 4. From Chem. Abst., **23**: 3607, August 10, 1929.—*R. E. Thompson.*

The Solubility of Silver in Water. H. Krepelka and F. Toul. Collection Czechoslov. Chem. Comm., **1**: 155-64, 1929. From Chem. Abst., **23**: 3616, August 10, 1929. Solubility at 20° reaches maximum of about 0.036 p.p.m. in about 21 days. Since no silver dissolves in water from which air and carbon dioxide have been carefully excluded, solution is due to direct oxidation to silver oxide. Solubility is slightly higher in glass vessels than in silver, probably because of alkalies dissolved from glass.—*R. E. Thompson.*

Recent Progress in the Study of Corrosion. G. D. Bengough. Chimie & industrie, Special Bo., 134-40, February, 1929. From Chem. Abst., **23**: 3652, August 10, 1929. Address reviewing Whitney's theory of corrosion and its modifications resulting from subsequent investigations. Article deals only with corrosion by water and by salt solutions.—*R. E. Thompson.*

A Rational Basis for Scale Prevention in Diesel Water Jackets. D. K. French. Oil Engine Power, **7**: No. 3, 170-2, 1929. From Chem. Abst., **23**: 3764, August 10, 1929. Complete, somewhat popular, discussion of causes of

scale formation in Diesel engine jackets and methods of prevention. Installations of small or moderate size, where erection of softener mav not be warranted, are given special consideration.—*R. E. Thompson.*

Water Filtration at Auckland, New Zealand. The Huia Filter Station. D. B. MANSERGH. Commonwealth Eng., **16**: 329–33, 1929. From Chem. Abst., **23**: 3763, August 10, 1929. Description of the Huia filtration plant, which is of Candy rapid gravity type and has ultimate capacity of 28 m.g.d. Data given on purification effected.—*R. E. Thompson.*

German Water Works in 1928. H. STRINGER. Engineer, **147**: 564–5, 1929. From Chem. Abst., **23**: 3762, August 10, 1929. Short account of water supplies of Shanghai, Cologne, Berlin, and Hamburg.—*R. E. Thompson.*

Boiler Operation at High Pressure Demands Exact Water Conditioning. R. E. HALL. Power, **69**: 873–5, 1929. From Chem. Abst., **23**: 3764, August 10, 1929. Caustic alkalinity should be 10–25 p.p.m. Use of phosphate as final conditioning chemical gives independent control of alkalinity and prevents scale formation at desirable low concentrations of alkali. Phosphate has none of disadvantages of sulfate. Its highly protective action is due to its part in forming impermeable film. Concentration of chloride in boiler water should be kept low because of its corrosive properties.—*R. E. Thompson.*

Boiler Feed Water Should be Free from Oxygen. Power Plant Eng , **33**: 566–8, 1929. From Chem. Abst., **23**: 3764, August 10, 1929. Description of newly modified WINKLER iodometric method.—*R. E. Thompson.*

Prevention of Boiler Corrosion by the Addition of Alkalies. A. SPLITTGERBER. Chem. Fabrik, 1929, 253–6. From Chem. Abst., **23**: 3764, August 10, 1929. Review, with references, of literature on prevention of corrosion and embrittlement by proper adjustment of alkali-sulfate ratio, and on use of sodium phosphate.—*R. E. Thompson.*

New Treasury Department Drinking Water Standards. H. N. OLD. Pub. Service Mgmt., **46**: 118–20, 1929 From Chem. Abst., **23**: 3763, August 10, 1929.—*R. E. Thompson.*

Comparative Tests of Chlorine Disinfectants. R. FETSCHER Z. Desinfekt. u. Gesundh., **20**: 78, 1928; Water Pollution Research Board Summary of Current Lit. **2**: 6, A146, 1929. From Chem. Abst., **23**: 3539, July 20, 1929. Tests of following disinfectants were made using *B. coli* as test organism: chloramine, pantosept I, II, III, pantosept tablets I and II, pantosept soda tablets, pantosept soap, caporit, magnocid, and chloride of lime. Chlorine contents were widely different, and disinfecting efficiency was not proportional to chlorine content. Alterations in chlorine content of any one preparation lead to corresponding changes in bactericidal properties. Chloramine-Heyden, containing about 24 per cent active chlorine has same disinfectant power as caporit, containing about 60 per cent. Magnocid is next most efficient, with

40 per cent active chlorine. Pantosept preparations show great variations in chlorine content and disinfecting properties. Pantosept soda tablets and soap cannot be used as disinfectants.—*R. E. Thompson.*

What the Delaware River Compact Does. CHARLES F. BREITZKE. Eng. News-Rec., 103: 112, July 18, 1929. Reply to B. FRANKLIN. Pointed out that proposed compact is simply an agreement between states of New York, Pennsylvania, and New Jersey, whereby they define their rights in Delaware basin, reserve as much direct control as possible to respective states and refer only matters of common interest to a commission, action by which can only be taken by unanimous consent of all 3 states. Watershed communities are exempted from operations of compact as far as possible.—*R. E. Thompson.*

Large-Volume Earth Handling Equipment in Germany. TH. KRAUTH. Eng. News-Rec., 103: 84–8, July 18 and 142–6, July 25, 1929. Detailed discussion of equipment developed in Germany for handling large volumes of earth. Material is excavated and loaded by continuous bucket excavators which have been built in enormous sizes, some of them weighing 550 tons and digging to depth of 100 feet.—*R. E. Thompson.*

Supplementary Water Supply for Kingsport, Tenn. H. F. WIEDEMAN. Eng. News-Rec., 103: 219–20, 1929. The original supply of Kingsport is impounded in a 175-million gallon reservoir, 6 miles from the city, which gives a static head of 622 feet on the distribution system. Objectionable color and turbidity necessitated construction of a filter plant, which was located directly below the storage dam. Following shortage of water in 1925 and 1926, an additional supply was developed from the South Fork of the Holston River, utilizing the head of the gravity supply for pumping. The old filter plant was abandoned and a new one constructed for treating both supplies, consisting of an aërator, gravity mixing chamber, coagulation basin providing 8-hr. detention period, two 1-million gallon per day rapid sand filters, and a 0.4-million gallon clear well.—*R. E. Thompson (Courtesy Chem. Abst.).*

Construction Progress on Dam for Owyhee Irrigation Project. Eng. News-Rec., 103: 248–9, August 15, 1929. Outline of progress on Owyhee dam. Diversion tunnel in right bank, which is 1000 feet long, circular in section, and 22.6 feet in diameter, inside concrete lining, was holed through on October 6, 1928. Lining has been almost completed and unwatering of site will be effected in near future.—*R. E. Thompson.*

Circular Trusses Support Planks Closing Tunnel Plug Keyway. Eng. News-Rec., 103: 228, August 8, 1929. Tunnel to be employed for river diversion during construction of Owyhee dam will later be used to discharge flood water from vertical shaft 300 feet deep connecting tunnel with circular spillway, necessitating plugging upstream from shaft connection. Method of providing for plugging outlined.—*R. E. Thompson.*

Tunnel Repaired with Precast Concrete Invert Beams. M. BLONDEL. Eng. News-Rec., 103: 138–40, July 25, 1929. Illustrated description of repair and

reinforcement of tunnel in Paris and Orléans Railway, France.—*R. E. Thompson.*

Effect of Percolating Water on Concrete Dams. N. A. Bowers. Eng. News-Rec., 103: 212–3, 1929. Conclusions formed from observation on a number of dams along the Pacific Slope are given and discussed. Leaching of Ca compounds and the resulting deterioration of the concrete are prevalent. The seepage water is in some cases supersaturated with salts dissolved from the concrete. In one dam a deposit of $CaCO_3$ 14 inches thick was found on the stairway of the inspection gallery. Percolation usually occurs at the joints between successive pours A standard permeability test is urgently needed. Strength tests are not a reliable indication of permeability.—*R. E. Thompson (Courtesy Chem. Abst.).*

Reconstructing a Drainage Ditch System. H. W. English and Albert S. Fry. Eng. News-Rec., 103: 97–100, July 18, 1929. In improvement of land drainage district of 430 square miles in Mississippi County, Ark., 416 miles of ditches were dug or enlarged, involving over 18 million cubic yards of earth excavation, nearly all of which was handled by dragline. Construction plant and methods described and illustrated.—*R. E. Thompson.*

Scarboro Water Works. Cont. Rec. and Eng. Rev., 43: 447–9, May 1, 1929. Brief illustrated description of recent additions to Scarboro Township, Ont., water works. Original plant, constructed in 1921, consisted of 24-inch steel intake extending ½ mile into Lake Ontario, pumping station, coagulation basin, two 0.5-m.g.d. rapid sand filters, and clear well. Extensions include duplicate basin, two 0.5-m.g.d. filters and 450,000-gallon clear water reservoir. —*R. E. Thompson.*

High Multiple Arch Dam Declared Safe Except from Earthquake. Eng. News-Rec., 103: 132, July 25, 1929. Board of consulting engineers appointed by state engineer of California has reported Lake Hodges dam to be structurally safe except in case of major earthquake shocks or overtopping. Dam is 10 years old and consists of multiple arch non-overflow section 390 feet long with maximum height of 133 feet. Board recommends improvement of spillway to discharge safely maximum predicted flood.—*R. E. Thompson.*

Venturi Meters and Standing Wave Flumes. C. C. Inglis. Eng. News-Rec., 103: 112, 1929. For pipe line discharge measurements the Venturi meter is unrivaled (cf. Herschel, C. A., 23: 3129). "Standing wave flumes" have several important advantages for open channels: (1) cost is less; (2) range is wider; (3) only 1 reading is required; (4) they can be designed to give proportional supplies—that is they do not interfere with the normal regime; (5) they can be combined with road bridges or falls. The standing wave flume has been perfected in India by E. S. Cramp. It is so designed that it discharges according to the broadcrested weir formula: $Q = C\ (3.09\ D^{1.5})$, C varying from unity for 1000 second-feet to 0.97 for 2 second-feet (See "Notes on Stand-

ing Wave Flumes and Flume Meter Falls." Tech. Paper No. 15: Bombay Pub. Works Dept. Obtainable from the High Commissioner for India, 42 Grosvenor Gardens, London, S. W. 1, for 4s. 6d.)—*R. E. Thompson (Courtesy Chem. Abst.).*

Insect Larvae Reduce Water Conduit Capacity. Eng. News-Rec., 103: 137, July 25, 1929. Accumulation of caddis fly larvae on walls of flumes and tunnels carrying water to certain hydro-electric plants of Southern California Edison Co. causes such serious decrease in capacity of conduits that annual removal is necessary. Larvae form slimy coating that is reported to reduce capacity of 620-second-foot conduit as much as 40 second-feet. Cleaning of larger conduits requires shutting off flow to permit men to scrape off the deposit. Smaller lines are successfully cleaned by forcing oak brush balls through by water pressure.—*R. E. Thompson.*

Hydraulic Jump Design for a 100-Second-Foot Conduit. J. W. Jourdon and Oren Reed. Eng. News-Rec., 103: 224–5, August 8, 1929. Illustrated description of hydraulic jump designed to reduce velocity of water at end of drop in small diversion canal of San Joaquin Light and Power Corporation from 35 to 3.5 feet per second to prevent excessive erosion.—*R. E. Thompson.*

Hydraulic Formulas Incorrect for Partly Filled Pipes. Charles W. Sherman. Eng. News-Rec., 103: 253–4, August 15, 1929. Actual measurements of flow of water in pipes show that none of standard formulas is correctly applicable to closed conduits partly filled, in which width of water surface diminishes as depth of water increases. Statement that mean velocity in circular conduit when half full is same as when full is not true in majority of cases. Although standard formulas are based upon assumption that friction between free surface of water and the air above it is negligible, this is not always the case. Value of n in Kutter's formula, computed from flow tests reported in literature, was nearly constant when every part of perimeter of stream of water was in contact with pipe, while, for anything less than full pipe, n varied both with depth and with sectional slope, although nearly constant for all depths in cases of very flat slope. It seems probable that computation by Kutter's formula, using such values of n as are commonly employed in designing sewers, will give as nearly correct results as can be obtained by any method now available; and that capacity of closed circular conduit when full will be somewhat greater than that obtained by formula with same value of n. It should be recognized, however, that it is not accurate, but merely a makeshift, allowable because no better method is known; and that inaccuracies are so great that computations of discharge from measured depths and slopes should not be attempted.—*R. E. Thompson.*

Low Rainfall in Great Britain During First Half of 1929. Eng. News-Rec., 103: 266, August 15, 1929. Rainfall in almost all parts of Great Britain for first 6 months of 1929 was less than 70 percent of average, while in some parts it was under 50 percent.—*R. E. Thompson.*

Diagram Gives Reactions at Pipe Bends. Earl M. Buckingham. Eng. News-Rec., 103: 230, August 8, 1929. Diagram given for obtaining reactions at pipe bends.—*R. E. Thompson.*

Sixty-Second Annual Report of the Commissioners of Water Works in the City of Erie, Pa., for Year Ending December 31, 1928. 95 pp. Annual report of Erie water works, consisting chiefly of extensive tabulations regarding financing, operation, and extensions, together with brief description of works and schedule of water rates. Estimated population of city is 129,000 and estimated population served 126,000. Daily average consumption was 24,116,109 gallons, equivalent to 191.4 gallons per capita or 108.95 after deducting water delivered through meters to industrial and large commercial users. Cost of supplying water, including collection, purification, pumping, and depreciation, was $21.553 per million gallons. Net addition of $212,506.98 was made to surplus during year and water was furnished for municipal purposes without cost to value of $55,722.26. Average cost of coal used was $2.948 per ton and number of gallons pumped per pound of coal consumed was 310. Average amounts of alum and hypochlorite used during year were 0.229 grains per gallon and 3.4 pounds per million gallons respectively. Wash water averaged 1.58 percent. Of 302 one-cc. samples of raw water examined, 107 contained *B. coli*, while of 596 ten-cc. samples of treated water none contained the colon bacillus.—*R. E. Thompson.*

Sanitary Engineering in the Carolina Piedmont. M. N. Baker. Eng. News-Rec., 103: 255–6, August 15, 1929. Progress in sanitation in North and South Carolina is outlined, with particular reference to the work of the North Carolina State Board of Health. If improved sanitation is not reflected so markedly in typhoid death rate as might be expected, it may be due to residual typhoid—typhoid that persists after public water supply has been made safe. Typhoid is much more prevalent among black population than among the white, but even for latter, rate is higher than average obtaining in other parts of country.—*R. E. Thompson.*

More on Interstate Waters. Wm. Easby, Jr. Eng. News-Rec., 103: 231, August 8, 1929. Further discussion of proposed Delaware compact, with particular reference to effect on proposed new supply of Philadelphia.—*R. E. Thompson.*

The Bull Run Storage Dam for Portland, Ore. B. E. Torpen. Eng News-Rec., 103: 204–8, August 8, 1929. Illustrated description of construction of dam erected by Portland Water Bureau, which adds 31,000 acre-feet of storage to natural flow of Bull Run River, the source of water supply to city. Reservoir will permit regulation of river to minimum flow of 265 second-feet (170 m.g.d.). Mean annual per capita consumption is 106 gallons per day, with peak month averaging 162. Consumers number 400,000. Estimated that added storage provided will meet city's needs for 30 to 40 years. Dam is of concrete gravity type, 200 feet high, arched on radius of 600 feet.—*R. E. Thompson.*

Lining Keeps Up with Driving on Water Tunnel. Eng. News-Rec., **103**: 173–7, August 1, 1929. Illustrated description of construction of 14-foot horseshoe section tunnel, 6.2 miles long, on Waterville hydro-electric development in North Carolina. Driving and lining are being carried out simultaneously owing to 2½ year time limit set for completing bore, a special steel form jumbo being employed which permits concreting without interrupting muck train operations. Two shafts, 662 and 639 feet deep, were sunk on tunnel line, one to be used as surge shaft, the other providing a 552-foot vertical drop for tunnel. Headings were started at 6 points, heading and bench method of driving being employed in each case.—*R. E. Thompson.*

Increasing Height of Small Dam for New Canaan Water Works. O. H. Marchant. Eng. News-Rec., **103**: 179, August 1, 1929. Brief illustrated outline of earth dam with masonry core-wall impounding water for supply of New Canaan, Conn. Dam was built in 1893, raised 10 feet in 1910 and additional 6 feet in 1928. Structure is now about 40 feet high and 500 feet long. Available storage is now 77.6 million gallons, an increase of 35 million gallons. Total storage is 107 million gallons. Estimated population is 2200.—*R. E. Thompson.*

Planning a Huge Diversion Weir: Bonnet Carré Spillway. W. W. De Berard. Eng. News-Rec., **103**: 242–8, August 15, 1929. Illustrated description of design of Bonnet Carré spillway and outline of experimental work carried out in connection therewith. Spillway, which is concrete dam with pier-and-weir section 7700 feet long located on north or left bank of Mississippi, 28 miles upstream from New Orleans, is being built primarily to protect levees at New Orleans from flood heights in excess of 20 feet (in relation to mean Gulf level). Preliminary work included study of methods of dissipating overpour energy to prevent scour.—*R. E. Thompson.*

Filtered Water Reservoir Used for Temporary Storage. Arthur B. Morrill. Eng. News-Rec., **103**: 228, August 8, 1929. A 20-million gallon reinforced concrete filtered water reservoir now under construction in Detroit, Michigan, on site of new Springwells station, which will not be ready for regular service for 2 to 3 years, will be employed for a time to relieve overloading of distribution system in certain sections of city. A temporary booster station will be erected in one corner. Reservoir will be filled during night and water will be discharged by booster pumps back into system during peak demand periods.—*R. E. Thompson.*

Economical Proportions of Storage Tanks. Robins Fleming. Eng. News-Rec., **103**: 171–2, August 1, 1929. Consideration of questions of minimum surface, minimum weight, and minimum cost of steel tanks for any given volume, presenting equations for diameter and height in terms of this volume for tanks of various types.—*R. E. Thompson.*

Engineering Features of Flood Control Plan Not Subject to Change by President. Eng. News-Rec., **103**: 186–7, August 1, 1929. Abstract given of report

of Attorney General to Secretary of War expressing opinion that engineering plans cannot now be changed except by Congress.—*R. E. Thompson.*

Sprinkler vs. Burlap in Concrete Pipe Curing. Eng. News-Rec., **103**: 220, August 8, 1929. Continuous sprinkling system, where cost of water permits, is preferable, this method more effectively maintaining whole pipe moist.—*R. E. Thompson.*

Test Head Designed to Prevent Leakage During Concrete Pipe Tests. Eng. News-Rec., **103**: 308, August 22, 929. Brief illustrated description of test head developed by American Concrete Pipe Co. for making hydrostatic tests on lengths of concrete pipe. Tests on 30-inch pipe have been made with pressures as high as 120 pounds per square inch.—*R. E. Thompson.*

Checking Phenol Pollution in Lake Michigan. Eng. News-Rec., **103**: 288, August 22, 1929. Health Department of Sanitary District of Chicago have made arrangements, in coöperation with 3 large companies operating by-product coke ovens, for preventing pollution of Lake Michigan by wastes from these plants. Waste from one plant will be pumped to city sewer, while that from other two will continue to be discharged into river as long as it has normal flow from lake to Chicago drainage canal. Whenever heavy rainfall or other conditions cause danger of reversal of flow, so that waste might be carried to lake, companies will be notified and will then store wastes until normal conditions of river flow are restored. Each company will provide storage capacity sufficient for 5 days production of waste.—*R. E. Thompson.*

The Detection of Nitrites in Drinking Water by Toluylene Red. A. Rochaix Bull. sci. pharmacol., **36**: 302, 1929. From Chem. Abst., **23**: 3763, August 10, 1929. Claim of priority referring to note of Vergnoux (C. A. **23**: 3037).—*R. E. Thompson.*

Purification of Potable Waters for Industrial Purposes. F. Diénert. Chimie & industrie Special No., 182–3, February, 1929. From Chem. Abst., **23**: 3763, August 10, 1929. Brief description of purity requirements for water for use in fermentation industries.—*R. E. Thompson.*

Waste Waters from Flax Retting. A. I. Rossolimo. Trans. Central Comm. for Protection of Water Reservoirs from Being Polluted by Ind. Waste Water (Moscow), **8**: 7–27, 1928. From Chem. Abst., **23**: 3766, August 10, 1929. Waste water from flax retting is treated with lime, which reduces organic matter 50–60 percent. Results are improved by addition of alum; 4.5 grams of lime and 2.5 grams of alum per liter are most satisfactory proportions. Precipitate is used as fertilizer. This treatment is followed by biological purification and 1:1 dilution with water.—*R. E. Thompson.*

The Composition of Waste Water from Flax Retting and Experiments on its Purification by Biological Treatment. A. V. Evlanova. Trans. Central Comm. for Protection of Water Reservoirs from Being Polluted by Ind. Waste

Water (Moscow) **8**: 29–55, 1928. From Chem. Abst., **23**: 3766, August 10, 1919. Waste water, after lime treatment, is subjected to action of anaërobic bacteria belonging to *Plectridium* type. Product is below the Health Department standards.—*R. E. Thompson.*

Electrolytic Oil Removal from Waste Manufacturing Liquors. H. Winkelmann. Chem.- tech. Rundschau, **44**: 82–3, 1929. From Chem. Abst., **23**: 3766, August 10, 1929. By this means oil, even in traces, is separated from waste waters as foamy agglomerate, which can be mechanicaly removed. Electrolytic separation is facilitated by addition of hard water or soda, or by treatment of liquors while hot. Energy requirements vary according to oil content from 0.15 to 0.20 kilowatt-hour per cubic meter. Labor requirements are low.—*R. E. Thompson.*

Determining Value of Pipe Coatings. K. H. Logan. Oil & Gas J., **27**: No. 50, 33, 87, 90, 94, 1929. From Chem. Abst., **23**: 3803, August 10, 1929. Accelerated tests as conducted by Bureau of Standards consist in exposing central portion of coated pipe to moist soil and measuring from time to time with microammeter the current produced by dry cell. Resistance of coating is then computed.—*R. E. Thompson.*

Residential Town Completes New Water Supply. Emmett J. Goodale. American City, **42**: 6, 101–102, June, 1930. The village of Williston Park, Nassau county, N. Y., originally supplied with water from Mineola, was recently incorporated and separate sources of water were developed by construction of two Layne wells, fitted with motor driven centrifugal deep well pumps with capacities of 750 to 800 gallons per minute, and of a 500,000-gallon elevated steel tank on tower 140 feet high. Water is pumped from either well, or from both, directly to riser pipe leading to splash type aërator, located above flow line of tank, which removes about two-thirds of the carbon dioxide present in well water. No other treatment is necessary, the well water being of safe sanitary quality. Cost of the development was $120,000.—*Chas. R. Cox.*

Adequate Income For All Water Works. F. Lewis. American City, **42**: 6, 109–10, June, 1930. This article presents statistical study of water rates in North Carolina. Average income per house connection in sixteen cities in North Carolina is $19.49 per year. Universal metering is practised in most North Carolina cities. The data are tabulated.—*Chas. R. Cox.*

Procedure for the Billing Division of a Municipal Water Works. American City, **42**: 5, 89–93, May, 1930. Detailed account of the procedure recommended by the Cincinnati Bureau of Governmental Research for adoption by the billing division of the Department of Water Works of that City. Forms are illustrated and tabulation given showing methods of billing in a number of large cities.—*Chas. R. Cox.*

Free Water for Municipal Departments. American City, **42**: 6, 87, June, 1930. The question as to whether water should be furnished free of charge by

municipal water works to parks, streets, public schools, or other city departments, is discussed by a number of municipal officials. Opinions expressed varied widely; one, for instance, being that water should no more be furnished without charge to city departments than should city owned water plants receive aid from the general tax fund to permit lower water rates; while, on the other hand, others feel that if the water works collect payment for water used by the municipality, it should likewise pay taxes. In general, the prevailing opinion seems to be that such water should not be charged for, but that it should be metered in order to check wastage.—*Chas. R. Cox.*

Water Costs Less Than Newspapers. WALTER ACKERMAN. American City, 42: 128–129, May, 1930. Abstract of a radio broadcast on charges for water service. It stated that water rates should cover expenses of operation, interest and sinking fund, funds for extensions and betterments, and the maintenance of the whole system. Rates should be adjusted to cover the foregoing and no more, and thus profits should not accrue in municipal water supply systems. A large portion of the cost of construction and operation of water supply systems is due to the necessity of providing fire protection, which, being a property benefit, should be paid for in proportion to the value of the property benefited and hence by general taxation.—*Chas. R. Cox.*

A Knowledge of Flow Tests is Helpful. HERBERT B. SMITH. American City, 42: 4, 143–45, April, 1930. This paper was originally presented before New England Water Works Association. Use of pitot tube and minometer for study of hydraulic conditions in distribution systems is discussed in detail, utilizing the distribution system of a community of 15,000 population as an example. It is concluded that costly expenditures for pumping station and filtration plant enlargements may be postponed several years in many cases, through location and repair of serious leaks, and that knowledge of the hydraulics of the distribution system permits many minor economies.—*Chas. R. Cox.*

Iron Removal and Softening Causes Increase in Consumption of Water. H. S. NIXON. American City, 42: 4, 155–156, April, 1930. Water supply of Vermillion, S. Dakota, is secured from wells located in valley of the Missouri river. This water contains in grains per gallon; sodium sulphate, 11.32; magnesium sulphate, 2.74; magnesium carbonate, 6.98; calcium carbonate, 19.25; and iron sulphate, 0.33. An iron removal and softening plant was constructed, with capacity of 400 gallons per minute, consisting of aëration chamber, mixing basin, sedimentation basin, filter beds, and the necessary chemical dosing apparatus. A cascade type of aërator is located within the filter room because of the cold climate. The mechanical mixing basin, with detention period of about 20 minutes, is provided with paddle making 10 revolutions per minute driven by 2-h.p. motor. The sedimentation basin provides detention period of 4 hours. Filter bed is of conventional type. Operation of the plant has been satisfactory. Iron has been completely eliminated and total hardness reduced to about 8 grains per gallon. Treated water is of attractive character

and marked increase in consumption of water has resulted. Total cost of plant was approximately $16,000.—*Charles R. Cox.*

Bacterial After-Growths in Water Distribution System. American Journal of Public Health, 20: 5, 45–89, May 1930. Report of the committee on water supply of the American Public Health Association reviews result of study of data collected from larger municipalities of the country relative to bacterial after-growths in water distribution systems and to influence of open filtered water reservoirs on bacterial content of water. Thirteen cities with one or more open reservoirs reported no bacterial after-growths in distribution systems. Five cities reported increase in *B. coli* content in the distribution system in sections where there was no possibility of water coming from an open reservoir. Two or three cities have noted occasional increases, but attribute them to causes other than growths in the mains. It is concluded that there is no positive evidence that such increase in bacterial content constitutes a menace to health, nor yet any way to determine to what extent it derives from pollution and to what extent from after-growths. Such increase in *B. coli* content renders unreliable the main criterion for judging the safety of water. Where there is a possibility of pollution, as when open reservoirs are used, increase in *B. coli* content should not be ignored even though there be evidence that this increase is due to growth in distribution system, or to multiplication of *B. coli* in reservoir. It is likewise concluded that the quality of a water supply should not be judged solely from results of examination of samples of the water entering distribution system, but that samples collected from all open reservoirs and standpipes at carefully selected sampling points should also be passed upon. The committee also urges that more study be given to open reservoirs, in the hope of reducing their number to a minimum. The indications are that it is a wise practice continuously to chlorinate water in open reservoirs.—*Charles R. Cox.*

Water Treatment With Chlorinated Copperas. CLINTON DECKER and H. G. MENKE. American Journal of Public Health, 20: 4, 357–64, April 1930. Chickasaw, Ala., water supply is secured from stream draining cypress swamps which ranges in color from 40 to 130 p.p.m.; in turbidity, from 3 to 50 p.p.m.; in alkalinity, from 2 to 5 p.p.m.; and in pH value, from 5.5 to 5.9. Various coagulants were tried in experimental treatment studies, including ferrous sulphate, alum, lime, and soda ash in various quantities and combinations. Best results were secured with 5½ grains of alum and 3 grains of lime per gallon. In the meantime, chlorinated copperas had been developed as a coagulant and tests therewith were carried out before the reconstructed filtration plant was completed which indicated that it was the best coagulant for local conditions. Copperas doses of 0.7 grains per gallon, oxidized by adding 1.5 p.p.m. chlorine, produced very satisfactory coagulation. The total chlorine dose was 2.16 p.p.m., as the chlorine demand of the raw water was 0.66 p.p.m. The addition of 0.4 grains per gallon of sodium aluminate improved the appearance and the rate of sedimentation of the floc. Coagulation could be secured with even smaller doses of coagulants, but not complete color removal. Addition of lime to the coagulated water was detrimental. The final alkali dose was,

therefore, added to the treated water, sufficient to adjust the pH to from 7.0 to 7.2.—*Charles R. Cox.*

Utilizing Marine Gasoline Engine as a Water Works Auxiliary Unit. W. C. Smith. Water Works Eng., 83: 8, 489, April 9, 1930. City of Oshawa, Ont., needed increased pumping capacity and found that, by changing the impellers and installing 200-h.p. motor, capacity could be increased to 1700 g.p.m. with practically the original efficiencies and at cost of $30 per horsepower year for additional power required. Due to further increases in consumption, engineers have recommended installation of new 3000-g.p.m. unit driven by 350-h.p., 400-volt motor. Because steam plant was so expensive to maintain, a 3000-g.p.m., 350-h.p., gasoline-driven pump was adopted as stand-by unit. This unit is never operated more than 100 hours per year and, at 25.50 per hour, its operating cost compares favorably with estimated cost of 41.50 per hour for a Diesel unit. Cost figures are based on gasoline at 20 cents, fuel oil at 12 cents, and coal at $7.55. The auxiliary low head equipment consists of 3000-g.p.m., 35-foot head, single-stage centrifugal pump driven by a 1000-r.p.m. Pelton wheel actuated by water from high head pump which delivers 3750 g.p.m., leaving 750 g.p.m. to be delivered into city mains. An electric generator driven by Pelton wheel furnishes the auxiliary source of light for night operation.—*Lewis V. Carpenter.*

Building Small Purification Plant at a Minimum Cost in Restricted Area. M. P. Hatcher. Water Works Eng., 83: 8,487, April 9, 1930. Iloa, Kansas, uses water from Neosho River which at times has hardness of 500 p.p.m. (mostly carbonate) and chloride content of from 500 to 700 p.p.m., due to oil well pollution. At present time water is settled and chlorinated. A new plant is being installed. Raw water will first be passed through plant turbine condensers to mixing chamber where lime will be added. It will be mixed for 9 minutes in oven and under baffled basin and passes to reaction chamber where it will be slowly mixed for thirty minutes by low head centrifugal pump giving it a spiral motion. It will then be aërated by means of Sacramento spray nozzles and carbonated with CO_2 from natural gas generating plant, after which it will pass to alum reaction tank and thence following a short sedimentation period, to the filters. Filtered water will be stored in three interconnected reservoirs beneath the plant. Chlorine will be added at entrance to last tank. Lime will be received in bulk and raised to top of building by bucket elevators. Alum will be received in 200-pound sacks. Both chemicals will be fed by dry feed machines.—*Lewis V. Carpenter.*

Why Water Mains Break. Frank A. McInnes. Water Works Eng., 83: 9, 559, April 23, 1930. What is commonly called rigid bearing is the greatest offender and is a condition due to uneven settlement, pipe being rigidly held at some points and inadequately supported in between. When pipe must be laid on solid support, it is good practice to place wooden blocking, laid on its side, directly under it. Before the wood has decayed, the earth will have compacted enough to support it. Wood blocking must not be placed on end as it is then nearly as unyielding as stone. Deep excavation in adjacent

ground is another cause of failure and the only remedies are, either to relay the pipe, or to see that the excavation is adequately braced. Water hammer is very dangerous if in filling pipes proper consideration is not given to removal of entrained air, or as result of operation of quick closing valves, which should not be permitted on system. Electrolysis, lightning, earthquake, frost, blasting, bad ground, and character of the pipe itself are other listed causes of failure. Chemical analysis has revealed that in most cases where pipe fails, material has been defective, with silica usually high and carbon low. Author calls attention to the necessity of thoroughly examining pipe for evidences of damage during transit.—*Lewis V. Carpenter.*

Operating Results from Well Arranged Iron Removal Plant. C. C. Foutz. Water Works Eng., **83**: 9, 557, April 23, 1930. Iron removal plant for LaPorte, Ind., includes aërating device consisting of 64 Sacramento type nozzles, discharging above a concrete splash tray. The water then passes upwards through aëration basin, 60 feet in diameter and 20 feet deep, where alum at rate of 80 pounds per m.g. is added, and then through mixing chamber to the 100-feet in diameter, 24 feet deep settling basin. Aëration period is 7 hours and settling, 19 hours. Settled water is filtered through rapid sand filters. Iron content of raw water ranges up to 15 p.p.m.; that of filtered water seldom exceeds 0.2 p.p.m. Filter runs average 55 hours and washing is easy as there is nothing filtered out except the iron. Operating cost of iron removal is $0.01343 per m.g.—*Lewis V. Carpenter.*

When is a Contractor Liable for Poor Water Works Construction? Water Works Eng., **83**: 10, 623, May 7, 1930. Under a certain contract, contractors had guaranteed to construct a water tight concrete tank and included among the specifications was the type of water-proofing compound to be used. The tank leaked and court held the contractors liable. The decision stated that, in spite of fact that contract specified the materials to be used and method of placing, it also specified a tank that would be watertight for one year and that part of the contract had not been fulfilled. Court held bank liable for cashing fictitious warrants forged by waterworks superintendent, an employee of the city. When loss of money is caused by a third party, the party that aided in fraud is responsible for any loss. Contractors bid on a job where the engineer's plans showed nature of subsoil as judged from result of a number of borings. No obstacles or impediments were indicated on the blueprints; but a clause in contract specified that contractor would be responsible for any unforeseen obstacles encountered. During excavation the contractor was forced to remove a large number of logs at considerable expense. Court ruled that contractor was not entitled to any extra on this account, because the condition encountered could have been ascertained by inquiry, as the site was that of an old saw mill. Court ruled that the logs constituted "unforseen circumstance in the prosecution of the same" under the terms of the contract and that the contractor was therefore responsible.—*Lewis V. Carpenter.*

New York to Rebuild Century-Old Croton Aqueduct as a Safety Measure. Wm. W. Brush. Water Works Eng., **83**: 11, 736, May 21, 1930. It has been

estimated that Greater New York will need 1,000 m.g.d. of water within the next three years. The old Croton aqueduct can be so repaired as to double its present capacity of 45 m.g.d. This offers the cheapest available source of temporary relief. The aqueduct was originally designed to flow partly full and, when filled, was found to leak, as the sidewalls were not heavy enough for the pressure developed. Plans are being prepared to reinforce all weak places during 1931 construction season. It is estimated that enough water will be available to keep the city supplied while repairs are being effected. The aqueduct masonry was constructed with Rosendale cement mortar and is generally in excellent condition.—*Lewis V. Carpenter.*

Overcoming Algae Troubles in a Clear Water Reservoir. BERNARD SIEMS. Water Works Eng., **83**: 11, 739, May 21, 1930. Greenville, Pa., has had plenty of trouble with algae in the clear water well, which is large and shallow, holding about 2.5 m.g. Algae grow in this basin practically the year around, mostly *Spirogyra*, but *Chaetophor Pisiformus* gives some trouble in the winter. About 40 pounds of copper sulphate was added and the water turned into the line after a few days. It has been the practice to add 1 p.p.m. copper sulphate daily to the sedimentation basin. The algae seriously interfered with chlorination on account of the tastes developed. On March 3 1930, ammonia was added and, after some adjustment, it was found that 0.6 p.p.m. of ammonia and the same amount of chlorine gave a water good (0.4 p.p.m. residual at the filter) from a bacteriological standpoint as well as tasteless. The two months try-out using ammonia has demonstrated that: (1) taste and odors have been eliminated; (2) effectiveness of sterilization has been greatly increased and much less chlorine is necessary than without the ammonia; (3) maintenance of residual chlorine in the clear water basins eliminated algae growth.—*Lewis V. Carpenter.*

How the Planets Affect Our Water Supply. CALEB M. SAVILLE. Water Works Eng., **83**: 11, 735, May 21, 1930. Observations have shown that there is greater tendency for rain in the quarter after full moon. The sun-spot phenomena have been established as recurring in cycles averaging about eleven years. It has not been definitely proved that the sun-spot and weather cycles are synchronous, but agricultural records seem to verify it. A study of climatic conditions over long periods of time and correlated with astronomical observations of the phenomena of the sun known as sun spots may reveal a relationship to recurring cycles of long periodicity affecting rainfall and run-off. Author cites the work that has been done on correlation of tree growth with climatological data and mentions that rainfall cycles do exist and that some people are convinced that there is too close an agreement between the harmonics of sun spot periods to be merely accidental. Scientists are not in accord on the exact relation that does exist.—*Lewis V. Carpenter.*

Water Works Revenue Takes Care of Bond Issue for Improvements. THOMAS L. AMISS. Water Works Engineering, **83**: 12, 883, June 4, 1930. Shreveport, La., created a mortgage bond issue of $500,000 on water works property and is using proceeds to construct an 8-m.g.d. filtration plant and other improve-

ments. Intake, piping, and pumping equipment are designed for 24-m.g.d. capacity. City has two independent plants, either of which can supply entire city for 8 months of the year. New plant is arranged with dry-feed machines feeding directly into mixing chambers. After filtration, water flows to aërators which reduce CO_2 from 20 to 3 p.p.m. Filter units are 1 m.g.d. each and are in the open. The filter operating room consists of a series of arches, closed in with steel sash and glass. All exposed concrete is to be brick veneered. The plant when completed will be one of the first in which rapid sand filters are in the open.—*Lewis V. Carpenter.*

Economics of Reservoirs. Paul Hansen. Water Works Eng., **83**: 12, 943, June 18, 1930. An impounding reservoir should be of sufficient capacity to provide an adequate supply to meet all demands during the intended period. On account of the cost of the structures, impounded storage should be provided for not less than 10 and sometimes for 20 to 30 years. Filtered water storage should not be provided to neutralize the differential between the rate of filtration and rate of consumption over a longer period than one day; it is more economical to provide more filters. The daily mass curve is advantageous in determining the filtered water storage. This type of storage and filters should be designed for at least 10 years. If possible, it is better to provide storage for the daily excess rather than excess filter capacity and storage at the filter plant is more convenient. In relatively level country where elevated tanks and standpipes must be used, economical storage is obtained by balancing cost of storage against cost of pumps. Where high ground is available near enough to the distribution system it will usually be best to have enough storage for the pumps to operate at uniform rate. In small systems sufficient storage may be justified to permit of off-peak pumping. Steel is generally conceded to be the most economical material for elevated tanks. Steel tanks elevated 100 feet above ground can be built up to 1,500,000 gallons with decreasing cost per unit of capacity. Concrete has been used for standpipes, but care must be exercised in their construction. The author lists four tables which compare the costs of elevated steel tanks, steel and concrete covered circular reservoirs, and concrete reservoirs protected and unprotected with earth embankments and covering. These tables give the unit cost for units of a large number of different sizes.—*Lewis V. Carpenter.*

When May City Adjust Rates to Pay Water Works Bonds? Leo T. Parker. Water Works Eng., **83**: 14, 1023, July 2, 1930. In a number of states where municipalities issue bonds for water works purposes it has been held legal to pay interest on bonds out of general taxation. Court in another case ruled that where a water company had been bought at a private sale, this sale price was sufficient valuation on the property for rate purposes and no further valuation was necessary. The higher courts reversed this decision and held that the company was entitled to rates on its existing valuation.—*Lewis V. Carpenter.*

Two Interesting Failures of Welded Patches on Large Steel Pipe. William W. Brush. Water Works Eng., **83**: 14. 1013. July 2, 1930. It is the practice

in collecting test specimens of welded pipe to cut a 6 x 14 inch plate out of the pipe and weld a patch over the hole. One such patch placed in September, 1928, after it had been in use five months under 60 pounds per square inch pressure, failed by a sudden rupture along the long side of the patch, the crack extending into the parent metal for several inches. It was repaired by cutting out the patch and welding along the crack. Temperature change was responsible for increased tensile stress in the metal to the extent of 9,000 pounds per square inch. The metal in the welds failed probably due to unequal cooling and the practice now is to rivet these patches rather then weld them. The author concludes that with proper precautions the longitudinal weld is good, but that one should not rely on a weld that must be followed by cooling between fixed points unless the metal is annealed.—*Lewis V. Carpenter.*

Self-Supporting Plant Formed Through Citizens' Holding Company. JOHN J. MURRAY. Water Works Eng., 83: 14, 1011, July 2, 1930. Litchfield, Ill., a town of 6,600 people, had a company-operated water system, but the water was not fit to drink. City voted to redeem the old plant and $60,000 in bonds was issued. A citizens' committee was organized and a $300,000 6 percent preferred stock issue was over-subscribed. A modern filtration plant has been built and the water-works is a paying proposition; it is estimated that in 20 years the plant will be entirely paid for.—*Lewis V. Carpenter.*

History of the Organization of the Portland Water District, DAVID E. MOULTON. Journ. New Eng. W. W. Assoc., 43: 3,359–63, December, 1929. The Portland Water Company was incorporated in 1866. Due to improper management and excessive profits, the water rates were exorbitant. After difficulties, political and otherwise, the company was purchased in 1907 by the municipality. Since that time the water rates have gone down, service has improved, and the properties have more than doubled in value.—*H. H. Gerstein.*

A Description of the System of the Portland Water District. JAMES W. GRAHAM. Journ. New Eng. W. W. Assoc., 43: 4, 364–9, December, 1929. The source of supply for the Portland water district is Sebago Lake, 17 miles from the city, which is fed by mountain brooks and streams. The water is soft and contains little mineral matter. In order to protect the water shed from pollution, two islands near the intake on which summer cottages were located and approximately 600 acres of lake shore on the lower bay, were purchased. In 1913 a law was enacted which prohibited pollution of the lake and the building of cottages or other structures within 200 feet of the shore. The law is enforced by a motor boat and shore patrol. A fully equipped laboratory tests the water daily from the lake and from the distribution system. The average chlorine dosage added in the gate house at the head of the main pipe lines is $1\frac{3}{4}$ pounds per million gallons.—*H. H. Gerstein.*

Beauty—An Investment. JOHN CALVIN STEVENS. Journ. New Eng. W. W. Assoc., 43: 4, 370–6, December, 1929. An investment in beauty in water works properties will bring dividends of great spiritual value. The additional

cost of making a strictly utilitarian structure architecturally interesting, without sacrifice of efficiency or convenience in the plant, need not run more than two to five per cent of the total cost.—*H. H. Gerstein.*

Watching the Weather in Safeguarding Public Water Supplies. Arthur E. Gorman. Journ. New Eng. W. W. Assoc., 43: 4, 377–81, December, 1929. Every water works system has one or more weak points, regardless of how well it has been designed and built and is operated. It is incumbent on the directing water works officials to know these weak links and their probable behavior when subjected to the strains that may be exerted by the many elements called "weather." Officials must know their factor of safety under extreme conditions which occur seasonally each year, and under unusual conditions which may be expected every 5 to 10 years. Shortage of water is a potential health hazard. Sharp outbreaks of water-borne diseases usually follow a simultaneous combination of circumstances which may not be repeated for many years. Careful water works officials should therefore always be on the alert for emergencies. While the writer was charged with the safety of the Chicago water supply, a chlorination control system was developed, based largely on a program of "Watching the Weather." By studying the effect of rainfall, winds, barometric pressure, lake levels and direction of river flow on the drift of pollution in the lake, it was possible to predict the degree of pollution at the intakes and to take measures necessary to protect the public water supply. The water works officials should inform the health authorities of existing weak points in the water works system. They should be notified of emergencies which develop or threaten to develop.—*H. H. Gerstein.*

Testing Large Meters. R. E. Ferguson. Journ. New Eng. W. W. Assoc., 43: 4, 382–6, December, 1929. Description of two methods of testing large meters: by use of (1) the Freeman Nozzle, and (2) a previously calibrated meter. Latter method is applicable for tests in the field.—*H. H. Gerstein.*

Reconstruction of the Woodlawn Pumping Station. H. F. Huy. Journ. New Eng. W. W. Assoc., 43: 4, 387–94, December, 1929. The Western New York Water Supply Company supplies the suburban area of city of Buffalo, and the shops and yards of the New York Central R. R., a territory having a population estimated at 120,000. The water supply is taken from Lake Erie through two intake pipes, one 20-inch and one 30-inch, extending one mile from shore. The screens which surmount the intake cribs are covered by about 22 feet of water. Debris and slush ice which tend to clog the screens are removed by back-flushing. A filtration plant constructed at main pumping station, was put into operation in December, 1928. It consists of 3.5-m.g. sedimentation basin, 16 filter units of 1 m.g.d. capacity each at normal filter rates, 0.75-m.g. clear well, and 0.2-m.g. elevated wash water tank. Detailed description is given of methods of construction, and of dimensions of the various units. Sulphate of aluminum is used as coagulant. At times copper sulphate is applied to combat algae troubles and prolong filter runs. Potassium permanganate is added for elimination of chloro-phenol tastes; chlorine is ap-

plied both before and after filtration, 70 per cent being added to the raw water and remainder to filter effluent.—*H. H. Gerstein.*

Some Uses of Aëration in Water Purification. MALCOLM PIRNIE. Journ. New Eng. W. W. Assoc., 43: 4, 395–8, December, 1929. Millions of dollars are needlessly lost annually in depreciation of water works distribution systems and destruction of plumbing, because of corrosive water supplies. All water fit for public water supplies can be made non-corrosive at a cost which is insignificant compared with the saving to investment in distribution systems and plumbing. Free CO_2 is the chief offender in alkaline waters. It may be expelled down to a residual of 2 to 4 p.p.m. by fine spray aëration. The residual can be neutralized by addition of small quantities of hydrated lime or caustic soda. Detailed data are given on operating results secured at West Palm Beach, Fla., Providence, R. I., Watertown, N. Y., and Danville, Va.—*H. H. Gerstein.*

Automatic Chlorination at Concord, N. H. PERCY R. SANDERS. Journ. New Eng. W. W. Assoc., 43: 4, 399–401, December, 1929. The Concord water supply is obtained from Pencook Lake, 3 miles north of city. From intake, which extends 2,200 feet into lake, water passes through brick conduit along the bottom and enters a gate house through two sets of screens. Chlorine is applied at the gate house, from which the water flows two miles to pumping station which pumps it to two million gallon reservoir. Since flow varies from 0.5 to 6.25 m.g.d., manually operated chlorination is out of the question. A Wallace & Tiernan automatic control vacuum chlorinator, feed of which is controlled by the head differential of a Venturi meter, was installed in 1928 and has proven satisfactory in continuously maintaining constant chlorine dosage with variable flow. The chlorinator had been operated several months before fact of its use was made public. As soon as consumers learned that the water was being chlorinated, numerous complaints concerning tastes, etc., were received. These have now ceased and the water is being chlorinated continuously.—*H. H. Gerstein.*

Enforcement with Other Beverages. J. FREDERICK JACKSON. Journ. New Eng. W. W. Assoc., 43: 4, 402–9, December, 1929. Although for many years there has been a state law in Connecticut prohibiting bathing in lakes, ponds, and reservoirs used for water supply purposes, there has been great difficulty in enforcing this measure; comparable with that of enforcing the prohibition law. A recent court decision, which upheld the legality of this statute, is being appealed in the Supreme Court.—*H. H. Gerstein.*

Changes in Power for Pumping at Newport, R. I. HAROLD WATSON. Journ. New Eng. W. W. Assoc., 43: 4, 410–15, December, 1929. High operating and maintenance cost of steam-driven pumping plant resulted in decision to install electrically operated equipment. The 6-m.g.d. steam plant was duplicated with electrical equipment without disturbing to any extent the steam outfit. Neither new building, nor addition to existing building, was necessary. Con-

trol of electric units is such that one man can handle both pumps and filters.—*H. H. Gerstein.*

Color Reduction in Storage Reservoirs. Caleb Mills Saville. Journ. New Eng. W. W. Assoc., 43: 4, 416–43, December, 1929. Present data supplement those previously presented in the N. E. Journal on phenomena relating to reduction of color, or decolorization, by long storage in reservoirs. Appendix includes calculations made in 1917 by Frederick P. Stearns on expected color of water from the Nepaug Reservoir of Hartford Water Supply Works, then under construction.—*H. H. Gerstein.*

The Rainfall of New England. Journ. New Eng. W. W. Assoc., 44: 1, 1–155, March, 1930. **General Statement.** Chas. F. Brooks. 1–5; **Historical Statement.** J. Henry Weber. 6–18; **Annual Rainfall.** J. Henry Weber. 19–31; **Seasonal Rainfall.** J. Henry Weber. 32–44; **Mean Monthly Rainfall of Southern New England.** J. Henry Weber. 45–56; **Minimum and Maximum Monthly Rainfall of Southern New England.** J. Henry Weber. 57–73; **Rainfall of Northern New England.** Gragg Richards. 74–99; **Average Rainfall Tables for Northern New England.** Gragg Richards. 100–105; **The Weather-Map Story of the Flooding Rainstorm of New England and Adjoining Regions, November 3 and 4, 1927.** J. Henry Weber and Chas. F. Brooks. 106–118; **Rainfall of New England During Storm of November 3 and 4, 1927.** X. H. Goodenough 119–155. A group of papers presenting data concerning Rainfall in the New England States.—*H. H. Gerstein.*

Rainfall in New England. X. H. Goodenough. Journ. New Eng. W. W. Assoc., 44: 2, 157–351, 1930. Presentation of monthly and annual rainfall rates, computed from original records where possible, from all of the available sources in New England area. Some records go back more than 100 years.—*H. H. Gerstein.*

NEW BOOKS

Studies of the Efficiency of Water Purification Processes. IV. Report on a Collective Survey of the Efficiency of a Selected Group of Municipal Water Purification Plants Located Along the Great Lakes. H. W. Streeter. Bulletin 193: U. S. Public Health Service, 1930. 100 pages. Fourteen plants selected for study were located as follows. Ohio: Ashtabula, Cleveland (2), Lorain, Elyria, and Sandusky. Michigan: Monroe, Wyandotte, Detroit, and Bay City. Indiana: East Chicago and Whiting. Illinois: Evanston and Winnetka. One outstanding physical condition causing difficulty in treatment of Great Lakes waters is absence of a prior, or coincident, change in turbidity with increased bacterial content. Indicated briefly, conclusions follow. (1) When aided by chlorination, average Great Lakes plant is nearly as efficient in bacterial reduction as average Ohio River plant; but decidedly less so, when unaided by chlorination. (2) A very considerable degree of variability exists among the several Great Lakes plants in respect to bacterial efficiency. In some cases this appeared to be associated with known differences in design

or operation, while in others such relation was not observed. (3) Variations observed in bacterial quality of raw waters and of effluents of individual plants appear to have about same general characteristics as observed in those of Ohio River type, but not as well defined, or as comparable, one with another. (4) The relationship observed between the bacterial quality of the raw waters and that of their corresponding effluents, under various conditions, were well defined and similar in nature to those observed along Ohio River. In general, this relationship may be expressed as $E^n = cR^1$, where R and E are the respective bacterial contents of the raw water and of the corresponding effluent at a given stage of treatment and c and n are empirical constants depending on stage of treatment and efficiency of process. (5) With aid of post-chlorination, average plant of the group surveyed produces final effluent conforming to primary requirement of revised Treasury Department standard from raw water containing *B. coli* not exceeding about 3300 per 100 cc. For average plant of a portion of the group, the corresponding limit approximated 4500 per 100 cc. Latter limit, while slightly less than corresponding Ohio River water figure, probably represents normal expectancy from the more efficient Great Lakes plants, with effective chlorination included. (6) Without aid of chlorination, the more representative average plant fails to produce effluent meeting same standard from raw water containing 5 to 10 *B. coli* per 100 cc. (7) Data not sufficiently extensive to afford reliable conclusions suggested that in order to meet both primary and secondary requirements of revised Treasury Department *B. coli* standard, final chlorinated effluents of some Great Lakes plants should contain not exceeding 0.5 to 0.6 per 100 cc. As judged by raw water criteria in (5), East Chicago and Whiting plants are clearly overburdened by excessive raw water pollution. Practically none of the other plants surveyed appeared to be overburdened in terms of the primary requirement of Treasury Department standard for chlorinated effluents. As judged by criteria in (7), however, Lorain and Wyandotte plants would also be regarded as overburdened, while those at Sandusky and Cleveland would be very close to the margin. From the evidence it seems possible that permissible raw water *B. coli* maxima of Great Lakes water might be raised by means of more highly elaborated plant features such as double-stage coagulation-sedimentation, or other auxiliary sedimentation devices. The relative economy and efficiency, however, could be demonstrated only by actual experience or large scale experiment. The efficiency of prechlorination of raw water burdened in excess of the maxima indicated, as at East Chicago and Sandusky, needs to be fully demonstrated. Need is pointed out for further observational study of following. (1) The underlying reasons existing for the lower bacterial efficiency of Great Lakes plants, as compared with that of plants treating river water, when unaided by post-filter chlorination, and for some of the unexplained variations in bacterial efficiency observed among the several Great Lakes plants. (2) The influence on the economy and bacterial efficiency of the Great Lakes plants exerted by differences in: (*a*) the relative amounts of coagulants used, (*b*) the retention capacities provided in settling basins, and (*c*) the rate of filtration and the depths and sizes of filtering medium. (3) The possible economy and efficiency of water purifications plants located along the Great Lakes and likewise of means for securing effluents of

more uniform bacterial quality." Further studies are also recommended in regard to (1) marginal zones of pollution centering around Lake Erie, (2) bacterial efficiency and quality of raw waters and effluents with particular respect to variations, and (3) a more exact and controlled experimental study of purification of Great Lakes water to confirm results of observational studies and of practical measures for increasing bacterial efficiency and minimizing variation in quality of effluents in current processes. "Because of the great importance of the Great Lakes region from the combined standpoints of population, commerce, industry, and recreation, the maintenance of safe and palatable water supplies along these Lakes constitutes one of the major problems of the country in this respect, affecting the health and economic welfare of millions of people." Numerous tables and plots accompany this valuable paper.—*R. E. Noble.*

Experimental Studies of Water Purification. IV. Observations on the Effects of Certain Modifications in Coagulation-Sedimentation on the Bacterial Efficiency of Preliminary Water Treatment in Connection with Rapid Sand Filtration. H. W. Streeter. **A. Observed effect of Variations in the Period of Sedimentation.** Public Health Reports. **45:** 27, 1521–1536, July 4, 1930. **B. Observed Effect of Certain Modifications in the Conditions of Coagulation.** Ibid., **45:** 28, 1597–1623, July 11, 1930. This excellent paper of two sections is well illustrated with tables and plots. Author's own summary and conclusions follow. These studies have been concerned with effects of variations in (*a*) period of sedimentation, (*b*) method of applying coagulant to raw water, (*c*) the pH of the coagulation reaction, and (*d*) density of coagulant added to raw water, on bacterial efficiency of coagulation-sedimentation as a preparatory treatment of water for rapid sand filtration and, incidentally, on efficiency of entire process of rapid sand filtration. The experiments were carried out during portions of the three years, 1926, 1927 and 1928, at a fully equipped experimental rapid sand water filtration plant of 160,000 gallons daily capacity, designed to typify, as nearly as possible, current large-scale practice but with certain additional features incorporated for experimental purposes. Results of study yielded the following main conclusions. (1) Substantial gains in bacterial efficiency of coagulation-sedimentation resulted from prolongation of nominal sedimentation period up to 8 or 9 hours and measurable gains with periods up to 12 hours. (2) Variations in pH of coagulation reaction from 5.6 to 6.9 produced little effect on efficiency of coagulation-sedimentation. Efficiency sharply diminished, with pH values exceeding 7 0 and slightly improved with pH values approaching 5.5. (3) Bacterial efficiency of double-stage coagulation, with two separate stages of sedimentation, was consistently greater than that of single-stage coagulation with one stage of sedimentation. Observations indicated, however, that with same total amount of coagulant and same total period of sedimentation, little if any difference was observable between the results shown by double-stage and single stage coagulation when carried out in conjunction with two separate stages of sedimentation. (4) A fairly consistent relation was shown between amounts of coagulant added to raw water and resulting bacterial efficiency, both of coagulation-sedimentation and of this stage in conjunction with filtration.

This relationship was found to hold irrespective of raw water turbidity or bacterial content, though more apparent when turbidity and bacterial numbers were higher. Measurable gains in efficiency were shown with increases in coagulant density ranging up to 5 grains per gallon. A general conclusion reached from foregoing series of experiments was that bacterial efficiency of rapid sand filtration processes can be increased very materially by means of longer periods of sedimentation and larger amounts of coagulant than ordinarily are used in current practice. The economical limit of sedimentation appears to be reached somewhere between 8 and 12 hours, with little gain in efficiency beyond the upper limit of time stated.—*R. E. Noble.*

The Eli Whitney Forest. RALPH C. HAWLEY and WILLIAM MAUGHAN. Bulletin No. 27. Yale University School of Forestry. This bulletin gives an excellent account of the value of scientific forestry over a long period of time. The Eli Whitney Forest is located on watersheds owned by the New Haven Water Company. In 1901 arrangements were made with this company whereby the wooded lands on a single tract of about 250 acres were placed under the management of the Yale School of Forestry. In the autumn of 1907 the New Haven Water Company decided to practice forestry on their entire holdings, which then comprised over 8,000 acres. With this idea in view the coöperative arrangement with the Yale School of Forestry was extended to all the company's lands. In planning systematically for the management of large areas of land, one of the first steps is to separate the land into various types. This calls for a logical scheme of classification based usually on the purpose for which the land can be used and the character of the existing vegetation. Ten classes have been recognized on this forest, as follows: Agricultural; Oldfield; Hardwood; Hemlock-hardwood; Pine; Hardwood swamp; Cedar swamp; Open swamp; Administrative and Barren, totalling 18,716 acres. The expense of reforesting the bare lands and of protecting and improving the entire forest has been met out of current income from sales of wood and timber. Until the planting of bare lands is completed, a balancing of current receipts and expenditures is all that can reasonably be expected. Once this stage is well past and the middle-aged stands commence to reach merchantable size, expenses will be lessened, a gradual increase in the cut of timber can be made, and enarged income will result. In addition to maps showing the location of the Forest, and a list of bulletins published by the Yale School of Forestry there are fifty-six fullpage photographs showing the various types of wood in each of the different classifications.—*A. W. Blohm.*

Effect of Sealing on Acidity of Mine Drainage. R. D. LEITCH, W. P. YANT, and R. R. SAYERS. Department of Commerce, Bureau of Mines, R. I. 2994, April, 1930. Samples of water were collected from both open and closed sections of a group of eight mines well scattered over a coal field in the southern half of Indiana. Particular attention was given to a comparison of the character of the water from open and closed sections of the same mine from the viewpoint of ascertaining whether the procedure of sealing abandoned and worked-out sections of coal mines decreases the formation of acid. The mines were selected at random, the only consideration being the opportunity of

collecting samples of both kinds of water in the mine to be visited. Conclusions: 1—Three of the eight mines so visited apparently had no acid water in either open or sealed workings. The remaining five had strongly acid water in open sections of the mine and alkaline water in sealed territory. No sample from an open section of long standing was alkaline. 2—Of all samples taken from sealed areas none had free sulphuric acid, and only one was potentially acid. 3—The evidence seems conclusive that the sealing of worked-out or abandoned sections of mines results in inhibiting acid formation. By sealing, it is assumed that the practical exclusion of air has been accomplished. 4—Observations indicate that seals may be contracted to be practically water tight, a fact that is often doubted by mining men. At any rate, they must be made air-tight by some means. It may or may not be necessary to provide a means of releasing pressure from these seals. 5—Considerable trouble and expense may be saved by mining companies, if the drainage is normally acid, by sealing such territory as soon as it is worked-out or for other reasons abandoned. 6—The comparison of waters from open and closed sections of mines agrees entirely with chemical theory and some laboratory experiments as to the factors governing acid formation in coal mines. In other words, if air (oxygen) is kept out of contact with pyritic material no acid will be formed, even though water is present in coal mines.—*A. W. Blohm.*

The Direct Count of Colon Aerogenes Organisms, its Possibilities and Promise. Paper by Fred O. Tonney and Ralph E. Noble. Manuscript, Bureau of Laboratories and Research, Chicago Department of Health. The authors feel that they have developed a medium suitable for routine use for direct plating and counting of coli-aerogenes organisms It yields in 42 to 48 hours not only the total count of the coli-aerogenes group, but also separate counts of the two principal members of the group, namely, the Bact. coli and Bact. aerogenes types. The practical advantages claimed for this method are: Greater simplicity than the fermentation methods; completed findings are obtained in 42 to 48 hours, presumptive indications are available in 36 hours, and it is a satisfactory means of purifying cultures. Deep colonies fished from a poured plate are more apt to yield pure strains than are surface colonies picked from Endo's medium or eosin methylene blue agar inoculated by the surface streak method.—*A. W. Blohm.*

The Fall River Conflagration, February 2–3, 1928. Supplement to the Factory Mutual Record of March, 1928, and Factory Mutual Record 5: 8, 5, Aug., 1928. Associated Factory Mutual Fire Insurance Cos., Boston, Mass. During the evening of February 2 and the early morning of February 3, fire swept through the business center of Fall River, Massachusetts. Before it was brought under control, it had destroyed a large vacant mill and had wiped out virtually six city blocks for an estimated loss of $6,000,000. Fall River is supplied with water by a direct pumping system from three pumps having capacities of ten, eight, and six million gallons a day. There are four standpipes—two located on hills at the north and south ends of the city, and two near the pumping station, each with a capacity of about one and a third million gallons. The average daily consumption is about six million gallons. Seventy pounds is

the normal pressure in the conflagration district, maintained by one of the three pumps at the pumping station. On the night of the fire pumps and standpipes combined gave a maximum rate of flow of about 23,000 gallons per minute. Of this about 4000 gallons per minute supplied normal demands. It is estimated that more than sixteen million gallons in excess of normal demands was supplied by the pumps and standpipes over the 24-hour period following the outbreak of the fire.—*A. W. Blohm.*

Conflagration at Nashua, N. H. H. E. Halpin and H. E. Magnuson. Fire Report "N," Assoc. Factory Mutual Fire Insurance Companies. 184 High Street, Boston, Mass. This is a report of the conflagration of May 4, 1930 which destroyed 2 factories, 2 churches, over 200 dwellings and several lumber yards for a loss estimated between two and a half and three million dollars. The water supply is pumped directly into a 4,000,000 gallon reservoir. At night the pump is shut down and the supply is by gravity from the reservoir. A six million gallon duplex pump driven by a water wheel performs most of the work. An 8-million gallon steam pump is used in winter when steam pressure is carried. A one million gallon centrifugal pump is held for emergency. After the fire started orders were given to raise steam for the steam pump. The pump discharge line to the reservoir was closed so that the pumps could raise the pressure in the distribution system by pumping against check valves on the discharge lines from the reservoir. During the height of the fire 73 lb. pressure was maintained at the pumping station and there was ample water in the reservoir. In the fire area the normal pressure of 50 lb. was reduced considerably. Twenty pounds was observed on the sprinkler risers at one location in the early stages of the fire. Fire department pumpers later exhausted the pressure in several locations. Several inches of vacuum were noted on suction gauges. Probably at least 6500 g.p.m. of the 7500 g.p.m. maximum draft went into the fire area. The system was overtaxed at a point where the gridiron was entirely too small to supply the demand. The excess use of water caused by the fire was 5,245,000 gallons, during the period from 2.00 p.m. Sunday and 9.00 a.m. Monday. The fire showed the need of having ample reserve water works pumping capacity available at once and larger distribution mains well looped, together with an ample grid system, to protect the industrial and residential districts and large lumber storage areas.—*A. W. Blohm.*

Direct Reading Humidity Recorder. Bulletin 880, 1930. Leeds and Northrup Company, Philadelphia, Pa. This bulletin describes the L. & N. Humidity recorder which records directly the relative humidity of air.—*A. W. Blohm.*